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A User's Guide to NTRM, A Soil-Crop Simulation Model For Nitrogen, Tillage, and Crop-Residue Management

ABSTRACT

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This book discusses how to operate the NTRM model; data needed to run it; how to use printed output, disk files, and plots in running the model; and the interactive programs available to create input files for NTRM. The book includes sample runs as examples of how to use the model.

KEYWORDS: agricultural management, crop residues, crop yield, infiltration, models, nitrogen, roots, soil, solutes, temperature, tillage, water

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Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Program listings, sample outputs, program user interactions, and all similar material have not been edited and are presented as they would appear to actual users.

Copies of this publication may be purchased from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. The Agricultural Research Service has no additional copies for free distribution.

Copies of the NTRM computer source and object codes together with test input and output data files may be obtained from the senior author. Your request should include six double sided, doubled density, 5 1/4" floppy diskettes for each NTRM copy desired.

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M.J. Shaffer and F.J. Pierce

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A USER'S GUIDE TO NTRM, A SOIL-CROP SIMULATION MODEL FOR NITROGEN, TILLAGE, AND CROP-RESIDUE MANAGEMENT

M.J. Shaffer and F.J. Pierce[1]

INTRODUCTION

The purpose of this manual is to provide the user with detailed operating instructions for the NTRM model (figs. 1 and 2). This is not a programmer's manual, and you should not expect to make model changes or additions based on the information given here. Before using this manual, read the related references pertaining to the model's concepts and theoretical basis (Shaffer et al. 1983, Shaffer and Larson 1987). The manual includes specific discussions of the types of data needed to run the model. Use or generation of all input and output media such as printed output, disk files, and plots are discussed in detail and a general output file summary is presented in appendix A. Use of NTRM is described for each major part of the model. This includes a discussion of the interactive programs that are available to create input files for NTRM. It is possible to enter the required input data and then receive output in the form of screen listings, printouts, or graphics. Sample runs have been included as examples of how to use the model. These are not exhaustive, and the casual user may want to consult the detailed NTRM model applications manual being developed to illustrate the many uses for the model.

The source program is written in FORTRAN 77 computer language for Control Data Corporation CYBER, CRAY Research CRAY-1A, HP A700, and IBM PC/XT/AT machines or true compatibles. The program as compiled under the IBM Professional Fortran (PROFORT) compiler requires about 512K to run on IBM PC/XT/AT machines.

Units in this manual are mixed between metric and English. Metric units are used except where experience has demonstrated a greater demand for the English equivalent. Future versions of NTRM will contain an option to allow the user to select the units that best fit local requirements.

[1]Shaffer is a research soil scientist, Agricultural Research Service, Soil and Water Management Research Unit, St. Paul, MN 55108, and Pierce is an assistant professor, Department of Crop and Soil Science, Michigan State University, East Lansing, MI 48824.

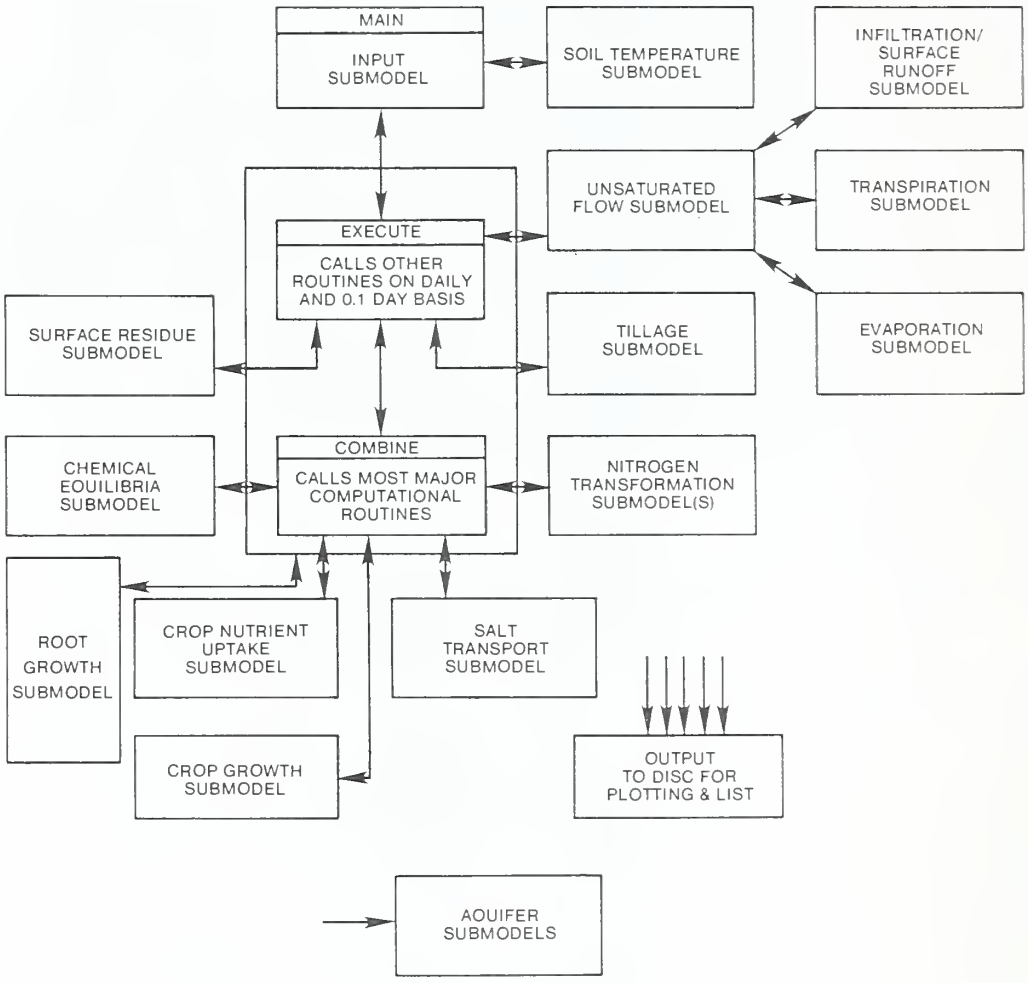

Figure 1
Nitrogen-Tillage-Residue-Management (NTRM) model.

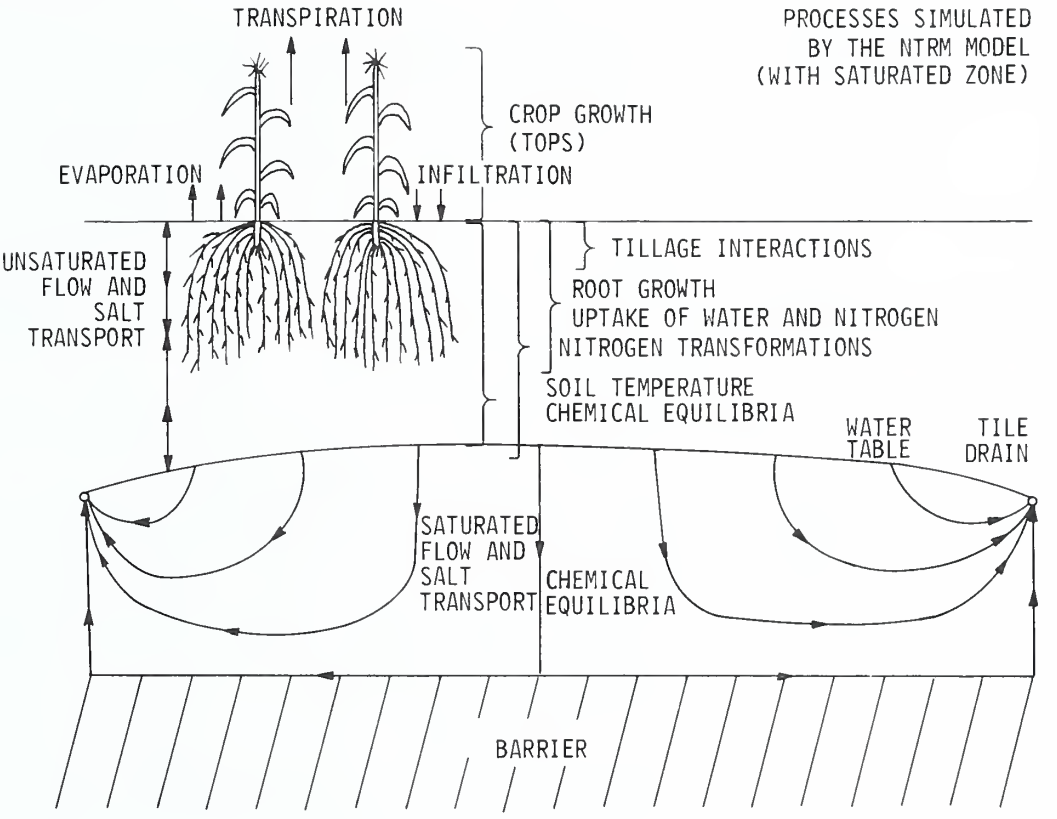

Figure 2
Processes simulated by the NTRM model
(with saturated zone).

NTRM MODEL INSTALLATION, SYSTEM CONFIGURATION, AND OPERATION

The NTRM model is available on floppy diskettes which contain a copy of the code for the major submodels and operating system together with a copy of sample input data and corresponding output. These programs run on IBM PC, XT, and AT computers or true compatibles with at least 512K RAM (640K recommended), a hard disk drive, floating point processor 8087 or equivalent, and DOS 2.1 or newer. The FORTRAN 77 source code has been included along with the object files for each program. In most cases, the linked executable files have also been included. It should be possible to compile and link the source code on computer systems other than IBM PC/XT/AT provided they are compatible with FORTRAN 77.

To get started with the model on the IBM PC/XT/AT or true compatible, we suggest that you set up a separate NTRM subdirectory on your hard disk and copy all the files from the supplied diskettes into that directory. You should also modify your CONFIG.SYS file to allow 18 files and 18 buffers. The linked NTRM model is too large to fit on a single 360K floppy diskette and must be stored on a hard disk or a 1.2 Mbyte floppy diskette. The object files should be linked using IBM Linker version 2.3 or newer.

Run the LKNTRMDE.BAT linker command file from the hard disk after the object files have been placed in the NTRM subdirectory. Let the linker create the default files by pressing RETURN when prompted. The executable file will be called NTRM1DE.EXE. In a similar manner, you should link the soil temperature submodel by entering LINK NTRMST.OBJ and pressing RETURN. The executable file for the soil temperature submodel will be called NTRMST.EXE. Test run the NTRM main model by entering NTRM1DE.EXE and pressing RETURN. Depending on which machine you have, the program will run to completion in about 40 to 60 minutes. Compare the contents of the output files just generated with the test files supplied (same names but with .TES extension added). In a similar manner, test the soil temperature submodel using NTRMST.EXE and compare the output created on files SOTEMP and AIRTEMP with SOTEMP.TES and AIRTEMP.TES. Finally, test the NTRM data file setup programs by entering RTEMP2.EXE and RNTRM2.EXE followed by RETURN.

The general configuration of the NTRM model is shown in figure 3. The entire model can be operated with user-supplied data by first using the appropriate input data setup routines and then running the appropriate executable files. It is also possible to obtain plots of data generated in current or previous model runs. Note that model input is file-oriented and that certain input files must be present in correct format whenever the model is run. The soil temperature submodel is a separate program with its own required inputs. These include max-min air temperatures and a general input file containing control data,

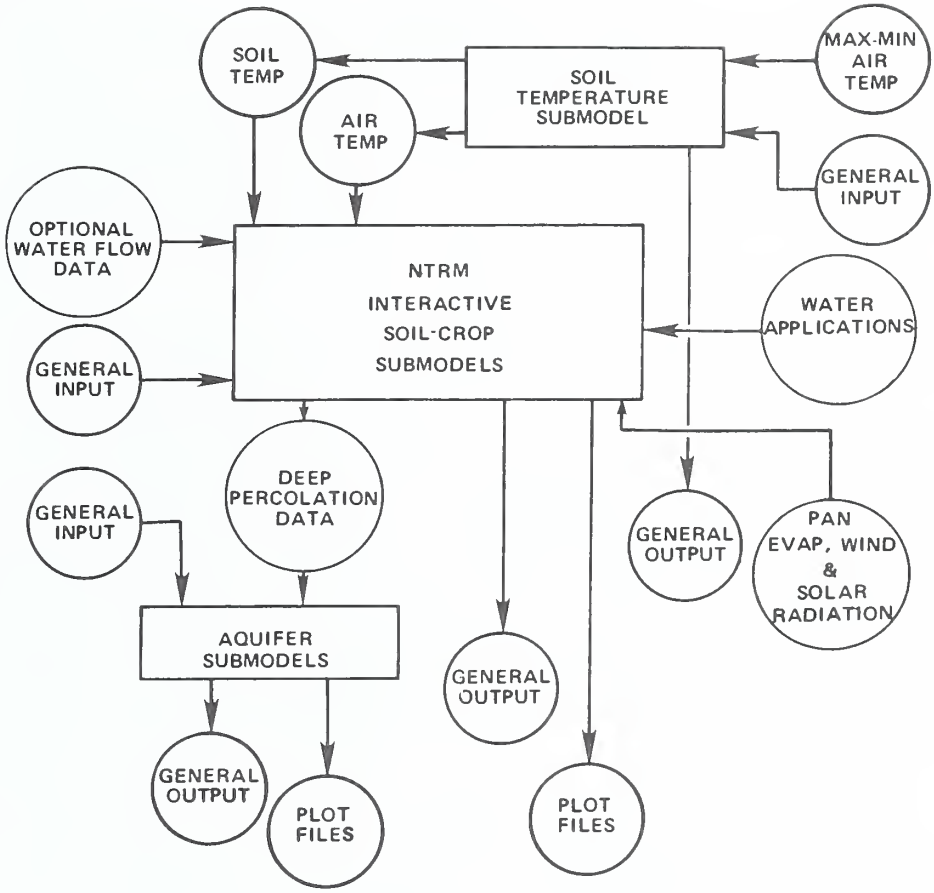

Figure 3
NTRM model -- general input and output configuration.

model parameter values, and initial conditions. This submodel is normally run first, and its output becomes input to the NTRM main interactive model.

This central soil-crop model requires input files containing (1) the water applications; (2) pan evaporation, wind, and solar radiation; and (3) general inputs for control data, initial conditions, and model parameters.

File names for running the central model must be established in a file called NTRFILE. Names for all required and optional input files and optional output files are specified in this file. File names are limited to seven characters or less. Output will be created in files with the names specified. If a particular output file is not desired, the word NONE should be entered and the corresponding file will not be opened or written. The following input and output file names must be specified in NTRFILE in the order shown below (one name per line).

Contents of NTRFILE:

Line No.	Description	Required (Yes or No)
1.	Common input file	Yes
2.	General output file	No
3.	Soil temperature input file	No
4.	Air temperature input file	No
5.	Precipitation and irrigation input file	Yes
6.	Pan evaporation, solar, and wind input file	Yes
7.	Deep percolation output file	No
8.	Top growth output file	No
9.	Root dry matter output file	No
10.	Daily roots summary	No
11.	Unsaturated flow output	No
12.	Nitrogen output file	No
13.	3-D plot output file	No
14.	Surface data output file	No
15.	N15 output file	No
16.	Evapotranspiration output file	No
17.	Special graphics control file	No
18.	Unsaturated flow data (may be input or output)	No

The aquifer submodels use output from the soil-crop model and require additional general inputs. These submodels have been described previously by Ribbens (1976) and by Shaffer and Gupta (1981).

Plot files generated by the various submodels are in a form suitable for listing or direct input to most plotting packages. A special interactive graphics system is available from the authors which allows direct plotting of NTRM plot files on TEKTRONIX and other graphical equipment. This system is a separate, stand-alone package that supplements the NTRM software described in this manual. In general, output from NTRM is suitable for input to a line printer; exceptions are certain optional binary files such as one version of the deep percolation file.

The NTRM interactive input file setup programs simplify the use of the model on microcomputers such as IBM PC/XT/AT. These programs were developed to simplify application of the model. Batch and card deck operation are also still possible via a mainframe or minicomputer, but the user is responsible for installation (including compilation) and maintenance of NTRM on these systems. Each file setup program is entered with a single system command. A series of menus and questions are then displayed to guide you through creation of the required input files.

SAMPLE PROBLEM

One of the best ways to learn how to operate a complex model such as NTRM is to follow through an example. For this exercise, we will assume that you wish to make runs using your IBM PC/XT/AT or true compatible machine. Your microcomputer should be equipped with a printer to record the data entered and the results. Graphics capabilities in the form of a display . screen and/or plotter are highly desirable, particularly if the equipment is compatible with TEKTRONIX code.

For this example, we will assume that you wish to make a short test run with the NTRM model using data contained in a field notebook. The most common starting place for NTRM runs is to create two files containing (1) the daily max-min air temperatures and (2) the general input data for the soil temperature submodel. This can be done by running the NTRM file set-up program for soil temperature called RTEMP2.EXE. In addition, data could be uploaded from a remote microcomputer disk or tape unit. The data formats for these two files are described in "Common Input File for Soil Temperature Submodel" and in "Max-Min Air Temperature Input File for Soil Temperature Submodel". Once the files are saved on the disk, the NTRM soil temperature submodel NTRMST.EXE can be used to make the actual soil temperature simulation runs.

Please note that the microcomputer version of the soil temperature submodel requires that the daily max-min air temperature file be named AIR, and the general temperature input data file be named INPUT1. Once the AIR and INPUT1 files are prepared, the soil temperature simulation is run by typing NTRMST.EXE and pressing the RETURN key.

Please refer to appendix B for the results to expect when the NTRM operating system is used to set up the necessary soil temperature files and make a soil temperature simulation run. In this example, the max-min air temperatures are taken from the notebook and entered directly via the keyboard of the microcomputer. The general input file is also created using the same program. You are required to supply only initial soil temperatures, Julian starting date, length of the run, and management code. Other parameters are set to default values by the operating system. These can be modified by using one of the text editors on your microcomputer, such as EDLIN.

This particular simulation run created daily soil temperature and hourly air temperature files named SOTEMP and AIRTEMP, respectively. These are suitable for direct input into the rest of the NTRM model. The output file named OUTPUT contains general information in tabular form for listing on a line printer.

The next step in making the overall NTRM run involves creating a second general input file (the common input file), a water application file, and a pan evaporation file with the help of the NTRM file setup program RNTRM2.EXE. Refer again to appendix B for the results obtained from a sample computer session. Note that each of the required files can be created and stored on the disk using the NTRM operating system. In this case, the general input file will always contain some variables that are set to default values. The MS-DOS text editor can be used to modify these if necessary. It is also possible to create these files off line with a microcomputer or similar device and then upload them to your machine. In addition, the files can be entirely created on your microcomputer by using EDLIN or some other text editor or word processor program. This often involves modification of an existing file(s).

Once these files are available on your microcomputer disk, the NTRM program named NTRM1DE.EXE can be run to simulate the remainder of the soil-plant processes. However, first be certain that all the file names have been correctly specified in the control file NTRFILE. Once this has been done, the simulation is initiated by typing NTRM1DE.EXE and pressing RETURN. Typical execution times on an IBM AT computer for a crop-growing season range from 20 to 50 minutes depending on the length of the run.

It is possible to save and preview plot files before the actual graphics output files are created. This often saves time and money when a new set of input data is being tried. This is done by specifying in NTRFILE which plot files to create and then bypassing (temporarily) the plots themselves. The plot files can be listed at a terminal or line printer for review. These files can then be converted to graphics output files by calling an appropriate graphics package. It is the graphics output files that are suitable for direct input into TEKTRONIX-compatible display tubes or plotters or into line printers (for plots).

INTERACTIVE GENERATION OF INPUT FILES

This section describes the portion of the NTRM model that assists you in interactive input of soil chemical and physical properties, crop growth data, management data (tillage and fertilizer), and climate data necessary to run the model. These data inputs are discussed in the sections of the manual on the operation of each submodel. When you operate the interactive system, please remember that some of the parameter specifications are set to default values and are therefore not immediately available for user input. The number of parameters in this category varies with the input option selected. You can always modify any of the parameter values later by using the EDLIN or similar text editor.

When you run either RTEMP2.EXE or RNTRM2.EXE, the operating system will ask you to enter names of files you wish to create. With the soil temperature file program RTEMP2.EXE, the system responds

```
ENTER CONTROL CODE:
1  =  CREATE MAX-MIN AIR TEMPERATURE FILE
2  =  CREATE GENERAL SOIL TEMPERATURE INPUT FILE
3  =  CREATE BOTH FILES
```

and with the central NTRM model file program RNTRM2.EXE, the system prints

```
ENTER FILES TO CREATE:
1 = COMMON INPUT FILE
2 = WATER APPLICATION FILE
4 = PAN EVAPORATION, WIND, AND SOLAR RADIATION FILE
7 = ALL OF THE ABOVE
NOTE:  TO GET COMBINATIONS OF THE ABOVE, SUM THE
       NUMBERS INVOLVED
```

Any combination of these files can be created. For each selection, you will be asked to enter a filename. You are also offered the option of stopping the program after each file creation or of continuing to the next portion of the operating system.

Remember, the operating system can be stopped at any time by typing CTRL C in response to any input queue. This, however, may result in loss of all data input in that procedure. A complete set of sample runs is presented in appendix B. These demonstrate the application of the model to an actual problem.

Creating Max-Min Air Temperature File

This subprogram asks you to enter the Julian starting day and a series of daily maximum and minimum air temperatures. Enter the temperature values free format with the maximum coming before the minimum in each case. Free format means that one or more values separated by blanks or commas can be entered anywhere on the same line. Stop entry of air temperature data by pressing RETURN in response to the prompt for a new line of data.

Creating General Soil Temperature Input File

This routine allows you to rapidly create a general file for use in making soil temperature simulation runs. You supply values for initial soil temperatures, key control parameters, and management options. Remaining parameter values are provided by default. These can be altered, if necessary, by using one of the text editors. Consult the appropriate sections of this manual for formatting details.

Creating Water Application File

The flow of data input for this file is shown in figure 4. The program to create the water application file has two parts. First, you are asked to input the number of water applications (up to 99) and some coded information.

```
THIS PROGRAM GUIDES THE USER IN THE
INPUT OF WATER APPLICATIONS DATA FOR NTRM

ENTER A NUMERIC IDENTIFIER CODE

ENTER YEAR OF THE RUN, EX., 1981

ENTER NUMBER OF WATER APPLICATIONS
(MAXIMUM NUMBER IS 99)

ENTER ALPHANUMERIC DESCRIPTION TO IDENTIFY
THE WATER APPLICATIONS
```

Next you are prompted to input the data and type of water application (R = rain; I = irrigation) and the amount (vol/unit area) for each water application.

```
ENTER MONTH, DATE OF MONTH,
AND AN ALPHANUMERICAL IDENTIFIER CODE
FOR THE TIME OF WATER APPLICATION 1 AND TYPE
(EX., 0121R=JANUARY 21, RAIN)

ENTER AMOUNT OF APPLICATION 1 AS A
VOLUME PER UNIT AREA (EX., INCHES)
```

On completion of input for the last water application, program control returns to the operating system, which selects the next procedure to run.

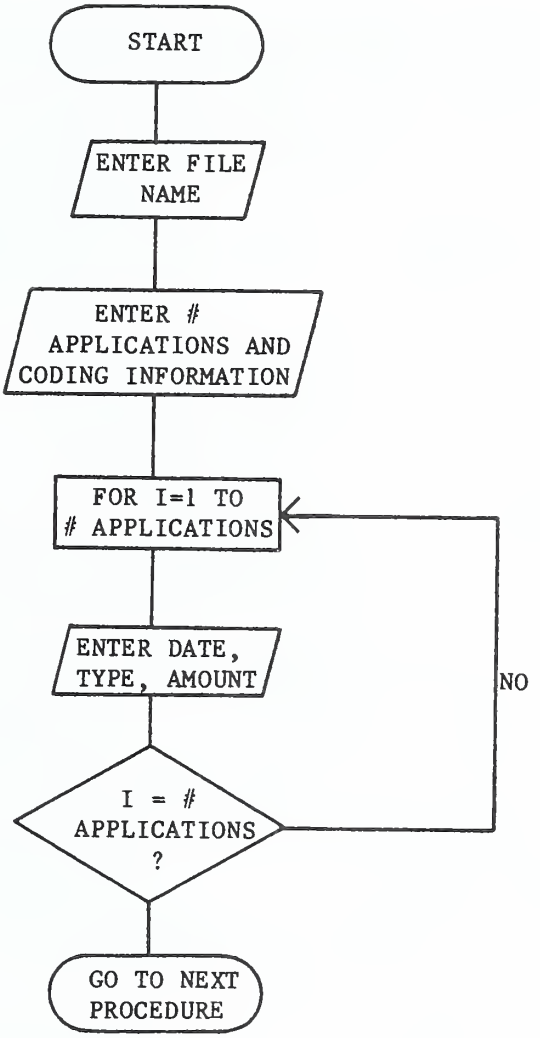

Figure 4
Flow of data input for the creation of water application file.

Creating Pan Evaporation, Wind, and Solar Radiation File

The flow of the data input for this file is shown in figure 5. Two options are presently available to enter pan evaporation data--semimonthly or daily (+ wind travel and solar radiation).

```
THIS PROGRAM GUIDES THE USER IN THE INPUT
OF PAN EVAPORATION DATA EITHER ON A SEMI-MONTHLY BASIS
OR A DAILY BASIS.  IN THE LATTER CASE, DAILY WIND
TRAVEL (KM/DAY) AND SOLAR RADIATION (LANGLEYS) ARE
ALSO REQUIRED.
```

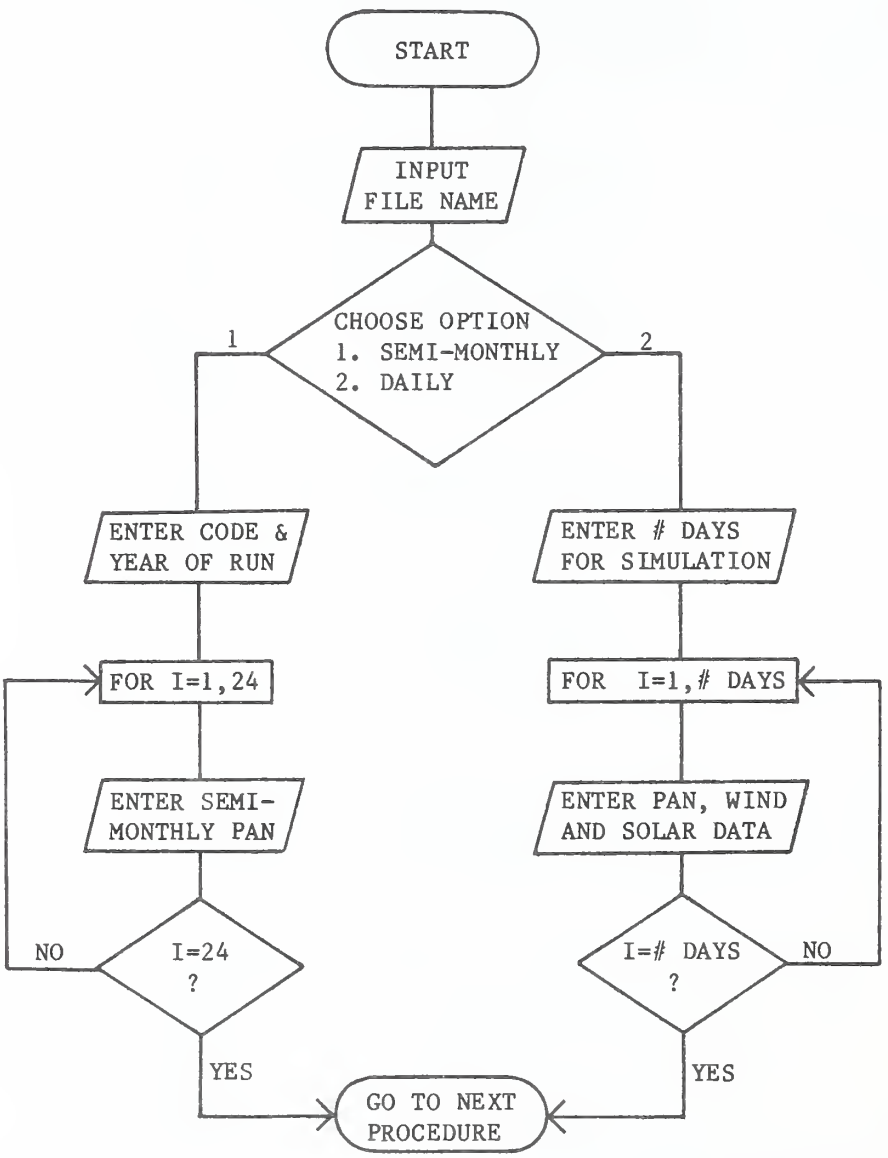

Figure 5
Flow of data input forthe creation of pan evaporation, wind run, and solar radiation file.

```
CHOOSE ONE OF THE FOLLOWING OPTIONS FOR PAN EVAPORATION

   0.  SEMI-MONTHLY PAN EVAPORATION
   1.  DAILY PAN EVAPORATION (+ WIND + SOLAR)
```

Semimonthly

For this option you must input a numeric code, year of data, and 24 semimonthly pan evaporation data (inches).

```
ENTER A NUMERIC CODE (MAX 5 CHARACTERS) THAT CAN BE USED
TO IDENTIFY THE CROP, CLIMATE, IRRIGATION METHOD, ETC.
(DISPLAYED ON OUTPUT)

ENTER YEAR OF THE RUN, EX., 1981

FOR EACH OF 24 PERIODS FOR THE YEAR, ENTER THE SEMI-MONTHLY
PAN EVAPORATION IN INCHES

ENTER PAN DATA FOR PERIOD 1
```

Daily

For this option, you must enter the number of days of the simulation run and the pan evaporation (inches) and wind travel (km/day) and solar radiation (langleys/day) for each day of the run.

```
THE PROGRAM WILL PROMPT YOU IN THE INPUT
OF DAILY PAN EVAPORATION, WIND TRAVEL, AND
SOLAR RADIATION.  THE PAN EVAPORATION IS IN UNITS
OF INCHES, WIND IS IN UNITS OF KM/DAY,
AND SOLAR RADIATION IS IN UNITS OF LANGLEYS/DAY.
(EX., .217, 193, 464)

ENTER THE NUMBER OF DAYS OF THE SIMULATION RUN
ON THE NTRM MODEL

ENTER PAN, WIND, AND SOLAR DATA FOR DAY 1
```

When all values have been entered, program control will return to the operating system, which selects the next procedure to use.

Creating Common Input File for Central Model

The flow of data input for this file is shown in figure 6. The system first requests the selection of an input option.

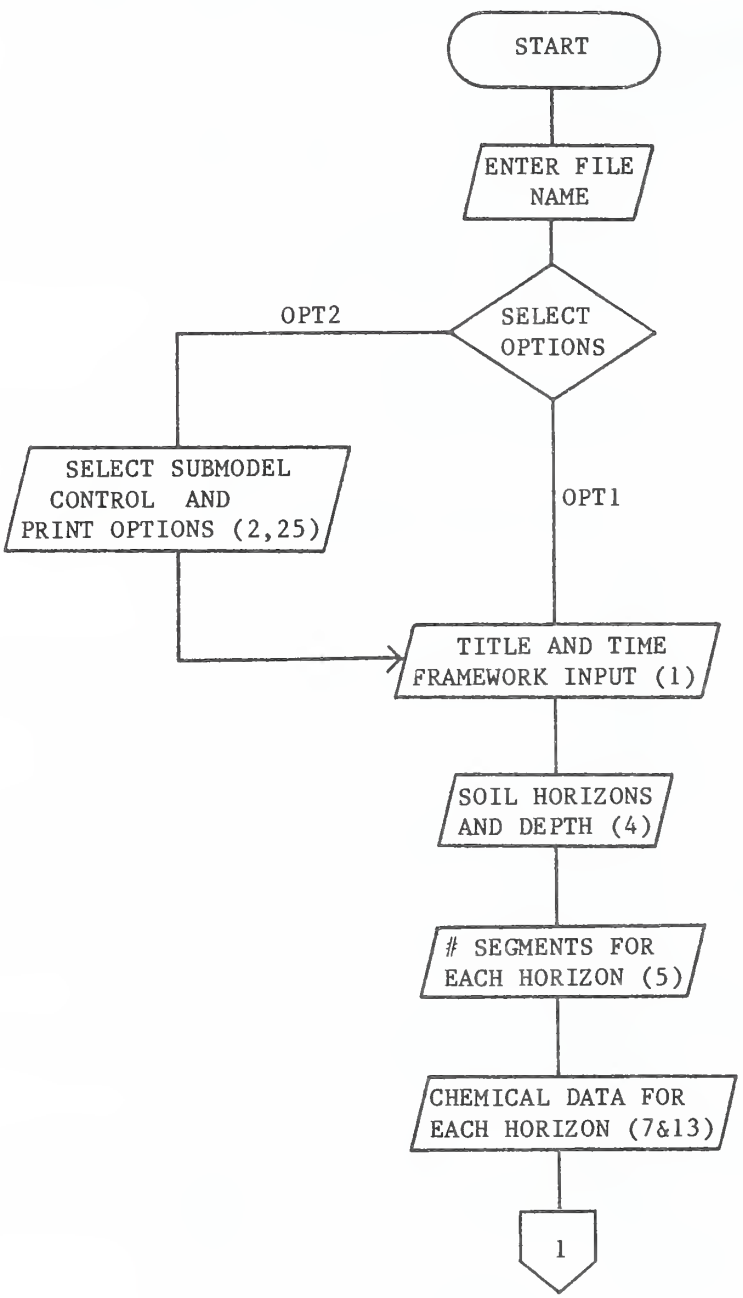

Figure 6
Flow of data input for the creation of common input file for central NTRM model. Numbers in parentheses correspond to data group.

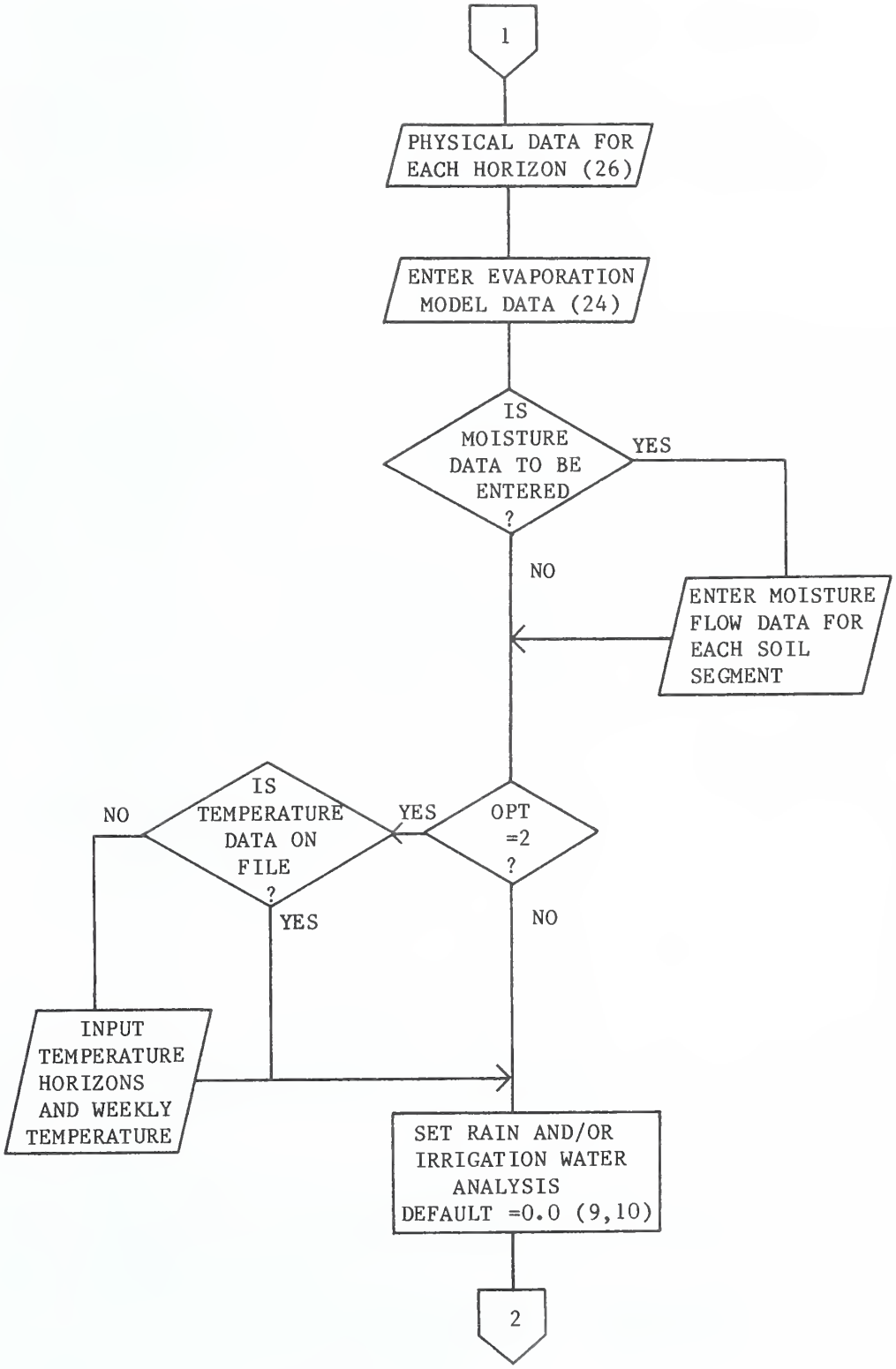

Figure 6--Continued

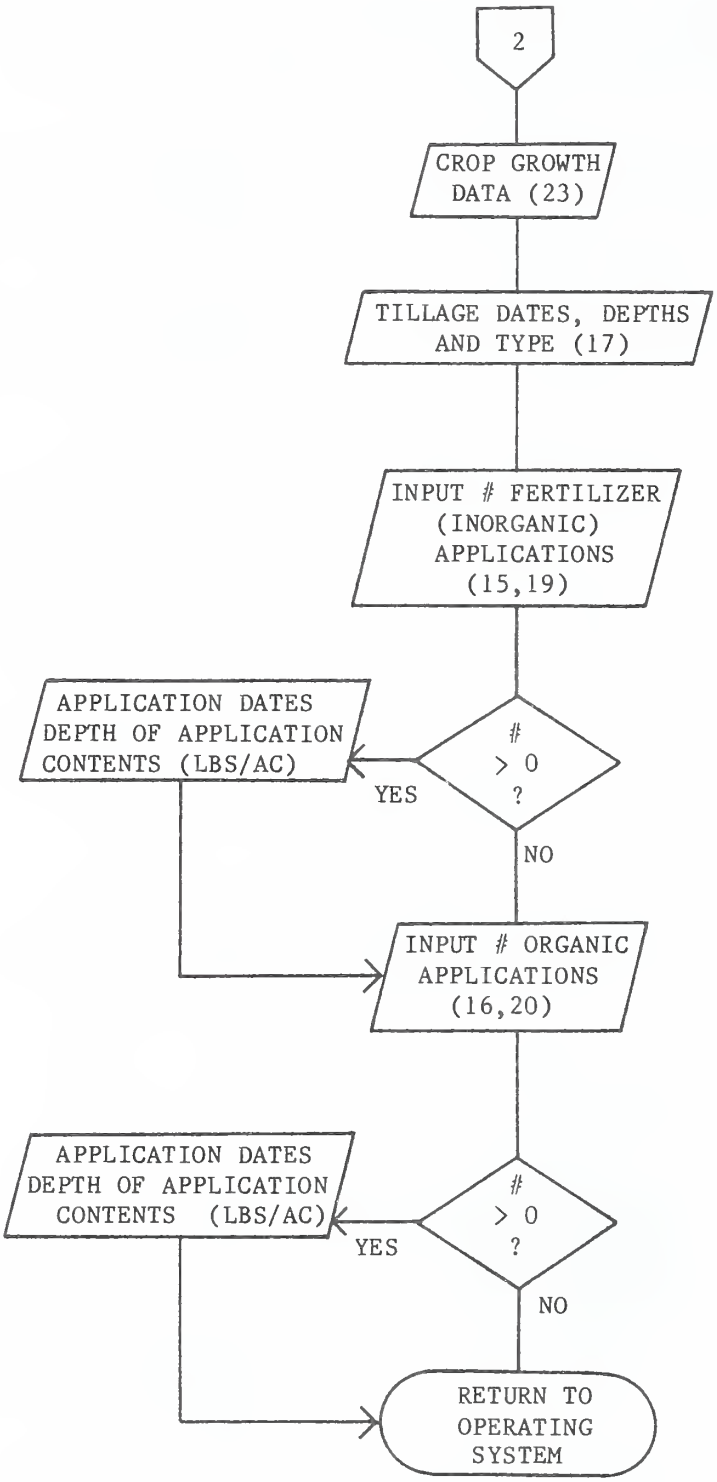

Figure 6--Continued

```
GENERATION SYSTEM FOR COMMON INPUT FILE
THE FOLLOWING ARE THE INPUT OPTIONS PRESENTLY AVAILABLE
IN THIS OPERATING PROCEDURE

  1.  DEFAULT OPTION 1 -- MINIMAL USER INPUT REQUIRED
  2.  DEFAULT OPTION 2 -- ALLOWS SELECTION OF SUBMODELS
                          UTILIZED, MORE USER INPUT MAY
                          BE REQUIRED

ENTER OPTION SELECTION
```

Option 1 is the short option, which minimizes the inputs required to run the model. This option is illustrated in the sample output presented in Appendix B. Option 2 expands the number of parameters you can set, including submodel, control, and print option selection. If option 2 is selected, the status of the submodel and control options are listed at the terminal and the user is asked to make the appropriate changes. When all the changes are complete, the new status of these options is again listed at the terminal. The status of the print options is then listed at the terminal, and you are asked to make the appropriate changes in these options.

```
THE FOLLOWING IS A SUMMARY OF THE
OPTIONAL SUBMODELS AND CONTROL SWITCHES

OPTIONAL SUBMODEL OR SWITCH                          DEFAULT

1.   NITROGEN TRANSFORMATIONS                          0
     A. 0 IF CONSIDERED
     B. 1 IF BYPASSED

2.   SALT REACTIONS                                    1
     A. 0 IF CONSIDERED
     B. 1 IF BYPASSED

3.   UNSATURATED FLOW MODEL                            1
     A. 0 IF READ FROM TAPE 1 OR TERMINAL INPUT
     B. 1 IF UNSATURATED FLOW SUBMODEL UTILIZED

4.   SOIL TEMPERATURE MODEL                            1
     A. 0 IF WEEKLY SOIL TEMPERATURES INPUT
     B. 1 IF SOIL TEMPERATURE SUBMODEL UTILIZED

5.   EVAPORATION MODEL                                 1
     A. 0 IF POTENTIAL EVAPORATION IS SET TO ZERO
     B. 1 IF POTENTIAL EVAPORATION IS ESTIMATED
```

```
6.   WATER FLOW DATA                                          0
     A. 0 IF TO BE READ FROM TAPE 1
     B. 1 IF TO BE INPUT FROM TERMINAL

7.   DEMAND FOR CROP GROWTH                                   0
     A. 0 IF CROP GROWTH INTERACTIVE WITH
        NITROGEN AVAILABILITY
     B. 1 IF CROP GROWTH IS IDEAL WITH RESPECT
        TO NITROGEN

8.   ROOT GROWTH CONTROL SWITCH                               0
     A. 0 IF ROOT GROWTH IS INTERACTIVE WITH
        SOIL CONDITIONS
     B. 1 IF ROOT GROWTH IS IDEAL WITH RESPECT
        TO SOIL CONDITIONS

DO YOU WISH TO CHANGE ANY OF THE ABOVE OPTIONS?

ENTER 1 FOR YES, 0 FOR NO

? 1

ENTER OPTION NUMBER YOU WISH TO CHANGE
(IF CHANGES ARE COMPLETE, ENTER 0)

? 2

ENTER NEW VALUE (1 OR 0) FOR OPTION 2

? 1

ENTER OPTION NUMBER YOU WISH TO CHANGE
(IF CHANGES ARE COMPLETE, ENTER 0)

? 0
```

Some of the submodel options are not available using the above-mentioned switches but rather are selected by the presence of additional data that are added to the common input file. These data must be added to an existing common input file for the central NTRM model.

```
THE FOLLOWING IS THE CURRENT STATUS OF THE OUTPUT OPTIONS

1.  PRINT INTERVAL (DAYS) FOR PREDICTED SOIL CHEMISTRY      2
2.  PRINT INTERVAL (DAYS) FOR SUMMARY OF NITROGEN
    BALANCE FOR SYSTEM                                     10
3.  TIME INTERVAL WITHIN A DAY ON WHICH 1. AND 2. ABOVE
    ARE TO BE ACTIVATED                                    10
```

```
4.  WRITE INTERVAL (DAYS) FOR OUTPUT TO TAPE 2          2
5.  PRINTING OF BASIC CONTROL CARD DATA                 1
6.  PRINTING OF INPUT DATA                              1
7.  WRITE N15 DATA TO OUTPUT TAPE 15                    0
8.  PRINTING OF INITIAL MOISTURE INPUT DATA             1
9.  PRINTING OF COMPUTED MOISTURE CONTENTS ON A
    DAILY BASIS                                         1

DO YOU WISH TO CHANGE ANY OF THE PRINT OPTIONS LISTED

ENTER 1 FOR YES, 0 FOR NO

? 0
```

Title and Time Framework

You are prompted to enter output title, beginning and ending date (Julian) of the run, and the date of crop emergence. If you have selected the plotting option, the title should end with the character "$."

```
  INPUT TITLE DESIRED ON PRINTED OUTPUT
  (1 TO 80 CHARACTERS)

  THE FOLLOWING INPUT SETS TIME FRAMEWORK
  FOR THE SIMULATION RUN
  INPUT JULIAN DATES FOR THE FOLLOWING
  STARTING DATE OF THE RUN =

  TERMINATION DATE OF THE RUN =


  ENTER JULIAN DATE FOR CROP EMERGENCE
```

Soil Horizons, Depths, and Segments

You are asked to input the number of soil horizons (up to 10) and the depth (cm) to the lower horizon boundary for each horizon. Maximum depth of the soil profile is not allowed to exceed 150 cm.

```
  THE FOLLOWING INPUT SETS SOIL DATA
  INPUT NUMBER OF SOIL HORIZONS (1 TO 10)

  ?

  INPUT DEPTH (CM) FROM SURFACE TO BOTTOM OF HORIZON 1

  ?
```

This last prompt is repeated for each soil horizon.

Next, you are asked to enter the number of segments per horizon. We recommend that the total number of segments for the entire soil profile be at least 10 to preclude error in the dispersion simulation (a message to this effect will be printed at the terminal if fewer than 10 segments are included).

```
ENTER NUMBER OF SEGMENTS FOR HORIZON 1

?

ENTER NUMBER OF NODAL SUBDIVISIONS IN
EACH SEGMENT (FOR HORIZON 1)

?
```

This will be repeated for each horizon.

Soil Chemical Data (Data Groups 7 and 13)

Both options 1 and 2 require input of soil chemical information. The required input for option 1 for each chemistry horizon is marked with an * in the example output (see below). The amount of input required for option 2 depends on the submodel section for the nitrogen transformation and salt reactions.

1. If both the nitrogen transformations and the salt reactions are not considered (status = 0), then only the bulk density for each horizon is required input.

2. If the nitrogen transformations are considered and the salt reactions are not considered, then the inputs required are the same as those for option 1 (the * inputs).

3. If the nitrogen transformations are not considered and the salt reactions are, then those inputs marked with a + are required.

4. If both the nitrogen transformations and the salt reactions are considered, then all the inputs listed in the example output are required.

```
* INPUT THE FOLLOWING SOIL CHEMICAL ANALYSIS FOR CHEMICAL
  HORIZON 1

* ENTER NH4+ (SOLUBLE FORM) (MEQ/L)
  (WARNING!! NEVER USE TOTAL NH4+ HERE)
```

? .027

* ENTER $NO3^-$ (MEQ/L)

? .009

* ENTER UREA (MEQ/L)

? 0

ENTER CA^{++} (MEQ/L)

? .2

ENTER NA^+ (MEQ/L)

? .15

ENTER MG^{++} (MEQ/L)

? .003

ENTER $HCO3^-$ (MEQ/L)

? 0

ENTER CL^- (MEQ/L)

? .02

ENTER $CO3^=$ (MEQ/L)

? .03

ENTER $SO4^=$ (MEQ/L)

? .03

ENTER EXCHANGE CAPACITY (MEQ/100G SOIL)

? 15

ENTER GYPSUM (MEQ/100G SOIL)

? 0

IS LIME PRESENT IN SOIL? 0.0 IF NO, 1.0 IF YES

? 0.0

* ENTER BULK DENSITY (G/CM^3 OF SOIL)

? 1.35

* ENTER GM WATER/GM SOIL IN SOIL EXTRACT

? 5

SINCE SALT REACTIONS ARE TO BE CONSIDERED, ENTER CO_2 PARTIAL PRESSURE (ATM) FOR HORIZON 1

? .008

* ENTER MICROBIAL BIOMASS (UG/G SOIL) AS CARBON

? 50

* ENTER NUTRIENT HUMUS (UG/G SOIL) AS CARBON

? 50

* ENTER MAXIMUM SURFACE INFILTRATION RATE (CM/DAY)

? 50.0

Soil Temperature (optional)

If option 1 is selected, you must have the soil temperature data on file in your catalog and this section of input will be bypassed. If option 2 is selected and you set the soil temperature parameter equal to zero, then you must enter the soil temperature horizons and weekly temperatures as follows:

THE FOLLOWING SETS UP TEMPERATURE HORIZONS AND DATA
ENTER NUMBER OF TEMPERATURE HORIZONS (1 TO 4)

? 1

ENTER DEPTH (CM) FROM SURFACE TO BOTTOM OF
TEMPERATURE HORIZON 1

? 150

ENTER NUMBER OF WEEKLY TEMPERATURES FOR THIS RUN

? 2

ENTER MEAN SOIL TEMPERATURE (C) FOR WEEK 1
FOR TEMPERATURE HORIZON 1

? 15

```
ENTER MEAN SOIL TEMPERATURE (C) FOR WEEK 2
FOR TEMPERATURE HORIZON 1

? 25
```

If you have the soil temperature on file, then set the soil temperature status as listed in the status section equal to 1 and this section of input will be bypassed. There is an option in the operating system to run the soil temperature model.

Waterflow Data (optional)

For option 1, the unsaturated flow model is selected by default. Therefore this section is bypassed. For option 2, this section is not necessary if the unsaturated flow model is selected or if you have waterflow data on tape. Note that the amount of input required for this option can be large.

```
THE FOLLOWING GUIDES THE USER IN THE INPUT
OF WATER FLOW DATA WHEN THE UNSATURATED
FLOW MODEL IS NOT USED AND THE FLOW DATA
IS NOT ALREADY ON A DATA TAPE.


ENTER WATER FLOW DATA FOR SOIL SEGMENTS

ENTER DEPTH (CM) OF WATER ON THE SOIL SURFACE

? 1

ENTER WATER FLUX ACROSS SOIL SURFACE (CM/DAY)

? 3

ENTER AVERAGE VOLUME (CM IN UNIT CROSS-SECTION)
OF WATER IN SEGMENT 1

? 5

ENTER WATER FLUX (CM/DAY) ACROSS LOWER BOUNDARY
OF SOIL SEGMENT 1

? 3

ENTER AVERAGE WATER TENSION (CM) OVER TIME
STEP FOR SOIL SEGMENT 1 (TENSIONS SHOWN AS NEGATIVE)

? -300
```

ENTER PLANT WATER UPTAKE (CM/DAY) FOR SOIL SEGMENT 1

? 1.5

ENTER AVERAGE VOLUME (CM IN UNIT CROSS-SECTION) OF
WATER IN SEGMENT 2

? 5

This is repeated for each segment entered previously.

Rain and Irrigation Water Analysis

This is always required. You have the option of setting either analysis to a default value of 0.0.

THE FOLLOWING WILL GUIDE IN THE INPUT OF RAIN AND IRRIGATION
WATER ANALYSIS

DO YOU WISH TO SET RAIN WATER ANALYSIS
TO DEFAULT VALUE OF 0.0. ENTER 1 FOR YES,
0 FOR NO

? 1

IS IRRIGATION WATER TO BE APPLIED
ENTER 1 FOR YES, 0 FOR NO

? 1
DO YOU WISH TO SET ANALYSIS TO DEFAULT VALUE
OF 0.0. ENTER 1 FOR YES, 0 FOR NO

? 0

If you choose to input water analysis, the following input requests will appear at the terminal.

ENTER THE FOLLOWING IRRIGATION WATER ANALYSIS
(UNITS ARE MEQ/L)

ENTER $NH4^+$

? .027

ENTER $NO3^-$

? .009

ENTER Ca^{++}

? 2.0

ENTER Na^{++}

? .5

ENTER Mg^{++}

? 1.0

ENTER $HCO3^{-}$

? 2.0

ENTER Cl^{-}

? 1.0

ENTER $CO3^{=}$

? 0.0

ENTER $SO4^{=}$

? 0.5

Crop Type and Coefficients

This information is always required.

ENTER THE FOLLOWING CROP GROWTH DATA

ENTER CROP MATURITY CLASS FOR CORN (IN DAYS)
EX. 85 = 85 DAY CORN, 110 = 110 DAY CORN, ETC.

? 85

ENTER PLANT POPULATION (PLANTS/HA)

? 56198

ENTER UP TO 10 CHARACTER NAME OF CROP VARIETY

? CORN TEST

Tillage Data Input

The following is required for both options:

```
THIS PORTION OF THE PROGRAM GUIDES THE USER IN ENTERING TILLAGE
INFORMATION

ENTER NUMBER OF TILLAGE EVENTS (MAX=6)

ENTER JULIAN DATE OF TILLAGE EVENT 1

ENTER DEPTH (CM) OF TILLAGE FOR EVENT 1

ENTER TILLAGE CODE.  1 = MOLDBOARD, 2 = CHISEL PLOW, 3 = DISK
```

Fertilizer Applications

You are asked to enter the number of fertilizer applications. If there were no applications, enter 0 and the remainder of the input is bypassed. If fertilizer was applied, you are asked for the Julian application date, the depth of application, and the content of the fertilizer for each fertilizer application.

```
THE FOLLOWING GUIDES IN FERTILIZER DATA INPUT
INPUT THE NUMBER OF FERTILIZER APPLICATIONS

? 1

ENTER APPLICATION DAY NUMBER 1 (JULIAN DATE)

? 121

THE FOLLOWING WILL SET UP FERTILIZER APPLICATIONS
FOR EACH FERTILIZER APPLICATION DATE

ENTER DEPTH (CM) OF A UNIFORM FERTILIZER APPLICATION
FOR APPLICATION DATE NUMBER 1

(IF = 0.0 A SURFACE APPLICATION IS INDICATED)

DEPTH =

? 4

ENTER LBS/ACRE OF NH4+ ADDED IN APPLICATION 1
TYPICAL RANGE 0-400 LBS/ACRE

? 25
```

ENTER LBS/ACRE OF NO3- ADDED IN APPLICATION 1 TYPICAL RANGE 0-1600 LBS/ACRE

? 40

ENTER LBS/ACRE OF UREA ADDED IN APPLICATION 1 TYPICAL RANGE 0-800 LBS/ACRE

? 0

ENTER LBS/ACRE OF CA++ ADDED IN APPLICATION 1 RANGE 0-20,000 LBS/ACRE

? 0

ENTER LBS/ACRE OF SO4= ADDED IN APPLICATION 1 RANGE 0-20,000 LBS/ACRE

? 50

ENTER LBS/ACRE OF CO3= ADDED APPLICATION 1 RANGE 0-20,000 LBS/ACRE

? 0

Crop Residue Applications

You are asked to enter the number of organic applications. If there were no applications, enter 0 and the remainder of the input is bypassed. If organic materials were applied, the application date, depth of application, and content are requested for each application.

THE FOLLOWING GUIDES IN ORGANIC RESIDUE DATA INPUT
INPUT NUMBER OF ORGANIC APPLICATIONS

? 1

ENTER ORGANIC RESIDUE APPLICATION DAY (JULIAN) FOR APPLICATION NUMBER 1

? 121

ENTER INCORPORATION DEPTH (CM) OF UNIFORM ORGANIC RESIDUE APPLICATION 1 (MUST BE A POSITIVE NUMBER) ENTER 0.0 FOR SURFACE APPLICATION

? 6

ENTER CARBON:NITROGEN RATIO OF ORGANIC MATTER ADDED IN APPLICATION 1 TYPICAL RANGE 15-80 (C:N RATIO OF 40:1 IS ENTERED AS 40.0)

? 40.0

ENTER ORGANIC NITROGEN ADDED (LBS/ACRE) AS OVEN DRY WEIGHT
TYPICAL RANGE 0-100 LBS/ACRE

? 56

The three previous questions are repeated for each organic application.

ENTER DEPTH (CM) OF RESIDUE ON SURFACE
TYPICAL RANGE 0-10 CM

? 5

ENTER FRESH RESIDUE REFLECTION COEFFICIENT

? .8

ENTER RESIDUE IDENTIFICATION CODE

0 IF USER WANTS TO ENTER S, THE FRACTION OF TOTAL RESIDUE WHICH IS LABILE

1 IF CORN STOVER

2 IF WHEAT STRAW

3 IF CELLULOSE

4 IF SOYBEANS

5 IF S IS TO BE CALCULATED FROM THE EQUATION
S = 0.07 + 1.11(1./ACN1)**1./3.

Note: ACN1 is the carbon:nitrogen ratio of residue added (Data Group 20).

When the organic residue data input has been completed, the data are written to disk file and program control is returned to the operating system.

RUNNING THE SOIL TEMPERATURE SUBMODEL

This section assumes that the user has successfully installed the soil temperature submodel on the computer and has been able to generate the required input data files AIR and INPUT1. Routine operation of the submodel involves computer runs with various climate input data files under different management schemes and initial conditions. The user is responsible for the file maintenance and storage associated with the many computer runs involved in a complex study. The file naming conventions used in this model require the user to rename output files after each run and to make certain that the correct input files are named AIR and INPUT1.

Once the common input file, INPUT1, has been created, related versions with minor modifications in management and initial conditions can be created using the EDLIN or similar text editor. Details concerning specific data items in this file can be found in the "Common Input File for Soil Temperature" section of this manual. Creation of additional max-min air temperature files can be done the most efficiently by using the interactive data setup program.

The starting day for the soil temperature runs should correspond to the starting day used in the general NTRM model. For example, if the soil temperature simulation starts on day 121, then the general NTRM run should also start on day 121.

Both the soil temperature and air temperature output files are structured for direct input into the general NTRM model. Be sure to enter the correct file names into NTRFILE before running general NTRM. The common output file, OUTPUT, is saved for listing or viewing at a later date. Be sure to rename this file if you want to save the results from each run.

COMMON INPUT FILE FOR SOIL TEMPERATURE SUBMODEL

The soil temperature submodel (Gupta et al. 1982) requires two input files and produces daily mean soil temperature and hourly air temperature output files suitable for direct input into the main NTRM model (fig. 7). Daily maximum and minimum air temperatures must be supplied in a file structured as shown in table 1. In addition, a general input file (control data), illustrated in figure 8, must be prepared as follows:

Data Group 1--Starting Day and Number of Nodes

Column No.	Var. type	Var. name	Variable description
Line 1 of 2			
1-3	I	JDSTART	Julian starting day for the run.
Line 2 of 2			
1-3	I	N	Number of nodes.[1]

Data Group 2--Node Depths and Initial Soil Temperatures

Column No.	Var. type	Var. name	Variable description
Line 1 of variable			
1-4	R	DP(1)	Depth of first node (cm).
5-10	R	TI	Initial (at time zero hour) soil temperature (°C) corresponding DP(1).
11-14	R	DP(2)	Depth of second node (cm).
15-20	R	TI	Initial (at time zero hour) soil temperature (°C) corresponding to DP(2).
.	.	.	
.	.	.	
.	.	.	

Repeat node depth and soil temperature to:

[1]Model is currently set up to handle 38 nodes (see example in section "Running the Soil Temperature Submodel").

Column No.	Var. type	Var. name	Variable description
51-54	R	DP(6)	Depth of soil temperature corresponding to DP(6).
55-60	R	TI	Initial (at time zero hour) soil temperature (°C) corresponding to DP(6).

Line 2 of variable

1-4	R	DP(7)	Depth of soil temperature corresponding to DP(7).
5-10	R	TI	Initial (at time zero hour) soil temperature (°C) corresponding to DP(7).
.	.	.	.
.	.	.	.
.	.	.	.

Repeat depth and soil temperature to:

51-54	R	DP(16)	.
55-60	R	TI	.

Line 3 of variable

Same format as above line--continuation of same data up to DP(N) and corresponding TI.

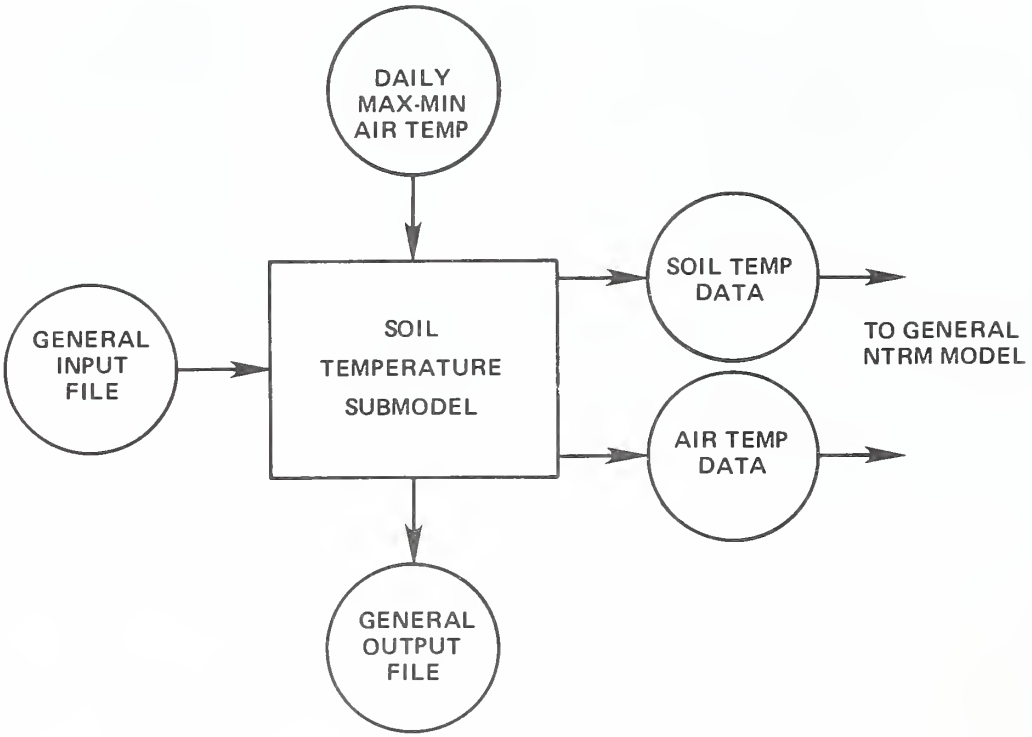

Figure 7
Input and output configuration for Soil Temperature submodel.

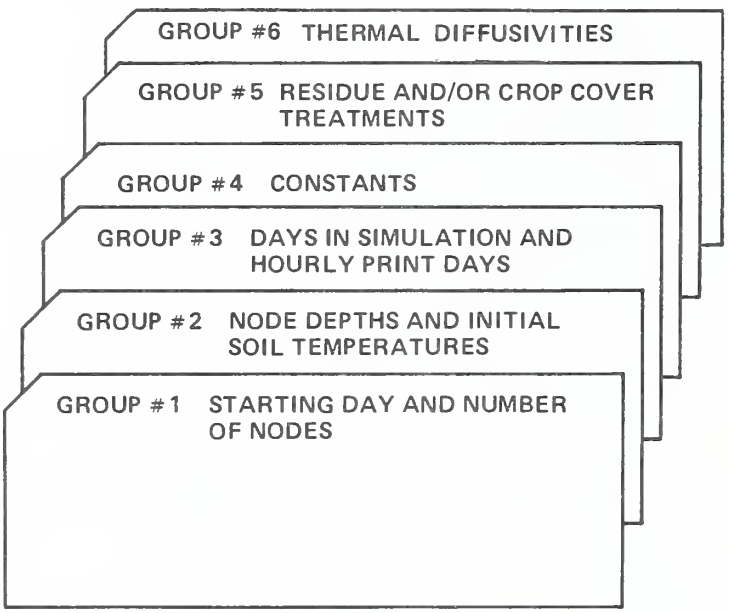
GROUP #6 THERMAL DIFFUSIVITIES
GROUP #5 RESIDUE AND/OR CROP COVER TREATMENTS
GROUP #4 CONSTANTS
GROUP #3 DAYS IN SIMULATION AND HOURLY PRINT DAYS
GROUP #2 NODE DEPTHS AND INITIAL SOIL TEMPERATURES
GROUP #1 STARTING DAY AND NUMBER OF NODES

Figure 8
Common input file (control data) for Soil Temperature submodel.

Table 1.
File structure for max-min air temperature data input file.

Record number	Type	Contents
1	Coded	Julian date, max air temperature (°F), min air temperature (°F), (spaced as shown below).
.	.	
.	.	
.	.	
N	Coded	Repeat for each day.

Details for records 1 through N:

Begin record		End record
Δ Δ Δ 1 2 1	Δ Δ Δ 6 2	Δ Δ Δ 4 2
1st field	2nd field	3rd field
6 characters	5 characters	5 characters

Note: Numbers must be right justified in these fields.

Data Group 3--Days in Simulation and Hourly Print Days

Column No.	Var. type	Var. name	Variable description
Line 1 of variable			
1-3	I	KLMX	Number of days in simulation. This is one day less than the number of days in the max-min air temperature file. Example: (Julian stopping day -Julian starting day (JDSTART)) = KLMX.[2]
4-6	I	LPRINT	If LPRINT = 0, the program does not print hourly soil temperatures. If LPRINT = 1, the program prints hourly soil temperatures for every day. If LPRINT = 2, the program prints hourly soil temperatures for a limited number of days.

[2]The model can currently handle up to 200 days. The program dimension size can be expanded to accomodate more days, if necessary.

Column No.	Var. type	Var. name	Variable description

If LPRINT = 2, the following lines are needed:

Line 2 of variable

1-3	I	NU	Number of days of hourly print (max = 200).

Line 3 of variable

11-3	I	NDAY(1)	Julian dates for hourly print.
.	.	.	.
.	.	.	.
.	.	.	.

Repeat to:

67-69	I	NDAY(23)	.

Line 4 of variable

.
.
.

Same format as above card--continuation of same data.

Data Group 4--Constants

Column No.	Var. type	Var. name	Variable description

Line 1 of 1

1-3	R	NX	This should be 1.

Data Group 5--Residue and/or Crop Cover Treatments

Column No.	Var. type	Var. name	Variable description

Line 1 of 1

1-3	R	TREAT	Defines the residue and/or crop cover treatment. 1 = bare soil 3 = 50% oat residue cover 5 = 75% oat residue cover 7 = 99% oat residue cover 9 = corn + 50% oat cover 11 = corn + no residue cover
4-6	I	MTH	This should be 1.

Data Group 6--
Thermal
Diffusivities

Column No.	Var. type	Var. name	Variable description
Line 1 of variable			
1-6	R	ALP(1)	Thermal diffusivity (cm^2/h).
7-12	R	(2)	
13-18	R	(3)	
19-24	R	ALP(4)	Thermal diffusivity (cm^2/h).
25-30	R	(5)	
31-36	R	(6)	
Line 2 of variable			
1-6	R	ALP(7)	
.	.	.	
.	.	.	
.	.	.	
Repeat to:			
73-78	R	ALP(19)	
Line 3 of variable			

.
.
.

Same format as above--continuation of same data up to ALP(N), N being the number of nodes specified in Data Group 1.

SOIL TEMPERATURE AND AIR TEMPERATURE
FILES (INPUT TO CENTRAL NTRM MODEL)

These input files are normally created by the soil temperature submodel. They are described here in detail to provide information for analysis and to permit inputs from other sources.

Soil temperature file (tape 20)

Record	Type	Format	Variable	Contents
1	Coded	(1X,F6.2,	DIST(1)	Depth to node 1 (cm).
1	Coded	F6.2,	DIST(2)	Depth to node 2 (cm).
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
1	Coded	F6.2,	DIST(20)	Depth to node 20 (cm).
1	Coded	11X,F6.2,	DIST(21)	Depth to node 21 (cm).
1	Coded	F6.2,	DIST(22)	Depth to node 22 (cm).
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Repeat to:

1	Coded	F6.2)	DIST(30)	Depth to node 30 (cm).
2	Coded	(13X,I3)	IDAY	Julian day.
3	Coded	(11X,F6.1,	TEMP(1)	Soil temperature for node 1 (°C).
3	Coded	F6.1,	TEMP(2)	Soil temperature for node 2 (°C).
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Repeat to:

3	Coded	F6.1,	TEMP(20)	Soil temperature for node 20 (°C).
3	Coded	11X,F6.1,	TEMP(21)	Soil temperature for node 21 (°C).
3	Coded	F6.1,	TEMP(22)	Soil temperature for node 22 (°C).
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Repeat to:

3	Coded	F6.1)	TEMP(30)	Soil temperature for node 30 (°C).

Record 1 is read once per run. Records 2 and 3 are repeated in sequence for each Julian day.

Air temperature file (tape 21)

Record	Type	Format	Variable	Contents
1	Coded	(6X,I3)	IDAY	Julian day.
2	Coded	(5X,F5.1,	AIRT(1)	Hourly air temperature (0000-0100).
2	Coded	F5.1,	AIRT(2)	Hourly air temperature (0100-0200).
2	Coded	F5.1,	AIRT(3)	Hourly air temperature (0200-0300).
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Repeat to:

2	Coded	F5.1)	AIRT(24)	Hourly air temperature (2300-0000).

Sequence of two records repeated for each Julian day.

This section assumes that the user has sucessfully installed the general NTRM model and has been able to run RNTRM2.EXE and generate the input files required to run this model. The general configuration of NTRM input and output files is shown in figure 9. Specific details of the file structures and data formats are given in appendix A.

Names for the input and output files must be specified in a file called NTRFILE. The model uses this file to set up the I-O for a particular simulation run. The user should rename any output files which must be saved before running the model again. Otherwise, the file will be overwritten with data from the new run.

The soil and air temperature files generated by the soil temperature submodel can be used as direct input to the model. The proper file names need only be specified in NTRFILE.

The control switches and initial soil properties are contained in the common input file. This file is the key to making various types of runs with NTRM. During routine applications, the common input file can be modified with the text editor to establish a variety of possible run configurations and initial soil properties. The user should become familar with the locations of various switches and control parameters in this file.

Output from the model occurs in three basic forms, (1) files intended for input to a graphics package, (2) tabular general output files with information intended for a line printer, and (3) files intended for input to other simulation models. In general, the graphics (plot) files can be examined using a text editor or line printer, but the lack of detailed formatting makes this process more difficult. The best way to use these files is via a plot package where visual comparisons can be done quickly and easily.

The general output files contain information such as soil constituent masses as a function of depth and time, a detailed mass balance summary for nitrogen, details of each water application event, top and root stress values over time, and soil water contents and suctions as a function of depth and time.

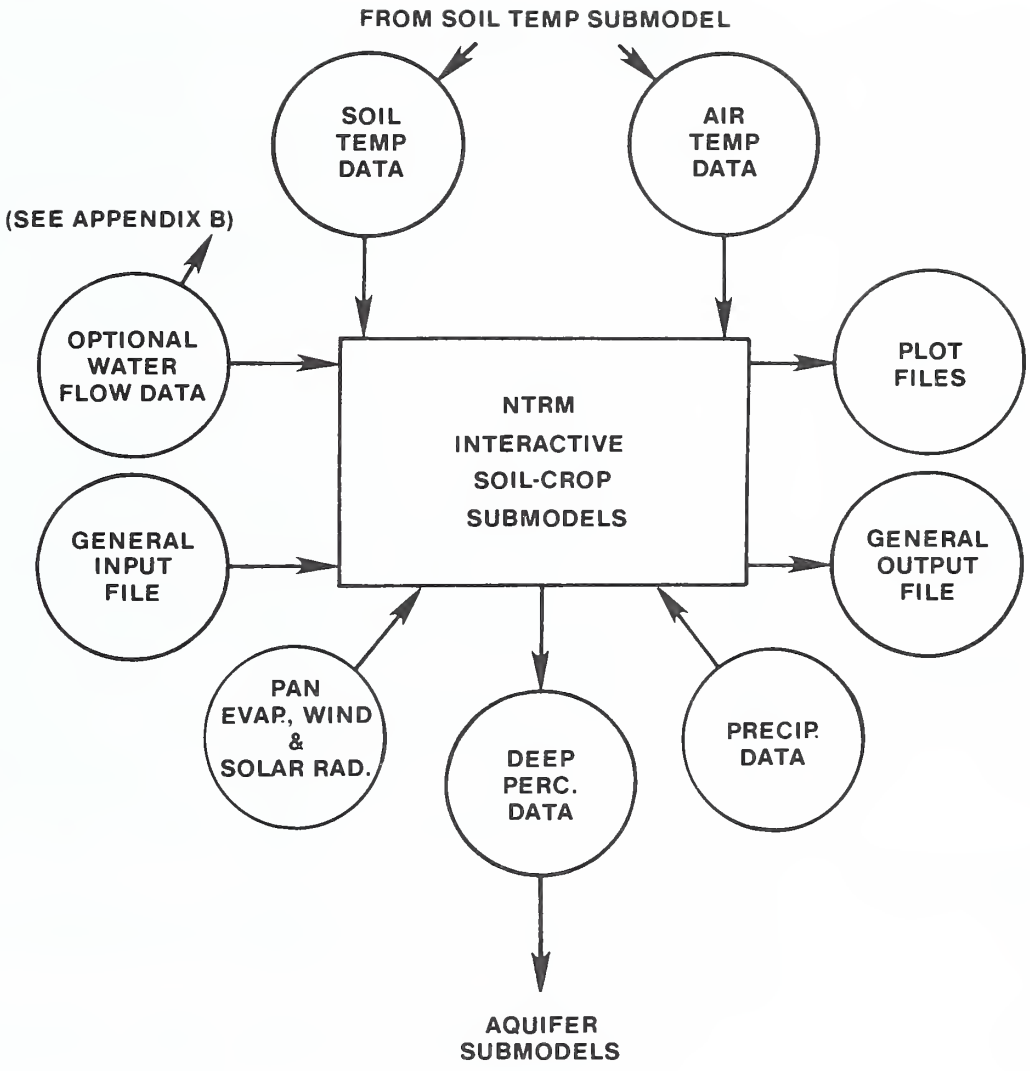

Figure 9
Input and output configuration for central NTRM model.

Whenever a new soil or crop configuration is established in the model, the model results should be checked against field validation data and basic experience. Some field conditions are difficult to simulate with only a casual inspection of the soil and climate properties. You could easily set up the model to simulate a set of conditions considerably different from those actually occurring in the field. This situation occurs because the user must always simplify the field conditions in order to fit them into the model. It is easy to omit certain key parts of the field system, while others are defined in too much

detail. Experience combined with a reasonable amount of field checking are required in order to set up a valid simulation.

The soil horizon, segment, and nodal structure used in the NTRM model are illustrated in figure 10. This one-dimensional configuration is set by the user before a run is started. The model may alter the spacing in the plow layer depending on the initial conditions and subsequent inputs to the system. The basic conventions for spacial configurations used in the model are outlined below.

Conventions:

1. Horizons are the largest subdivisions (max=10).

2. There are 1 to 24 segments per horizon.
   --most model calculations are done on a segment basis.
   --there can be a maximum of 24 segments in the soil column.
3. Nodes for flow calculations occur on segment boundaries or are evenly spaced between boundaries in each horizon. Nodal spacing is constant within each horizon.

4. The user specifies the number of horizons and the depth to the lower boundary of each.

5. The user specifies the number of uniformly spaced segments per horizon.

6. The spacing between segments is known as DELX. The spacing between nodes is known as DELXF (in most cases, DELX = DELXF).

7. The user specifies the number of nodes evenly spaced between horizon boundaries.

8. Segment (1) represents the soil surface and contains any crop residues or surface applications of fertilizer.

User Guide to Horizons, Segments, and Nodes

1. First set up the horizon locations based on available soils data.

2. Then subdivide the horizons into segments based on the detail desired therein.

3. Nodes must occur on each segment and horizon boundary.

4. Additional nodes can be added between horizon boundaries if necessary.

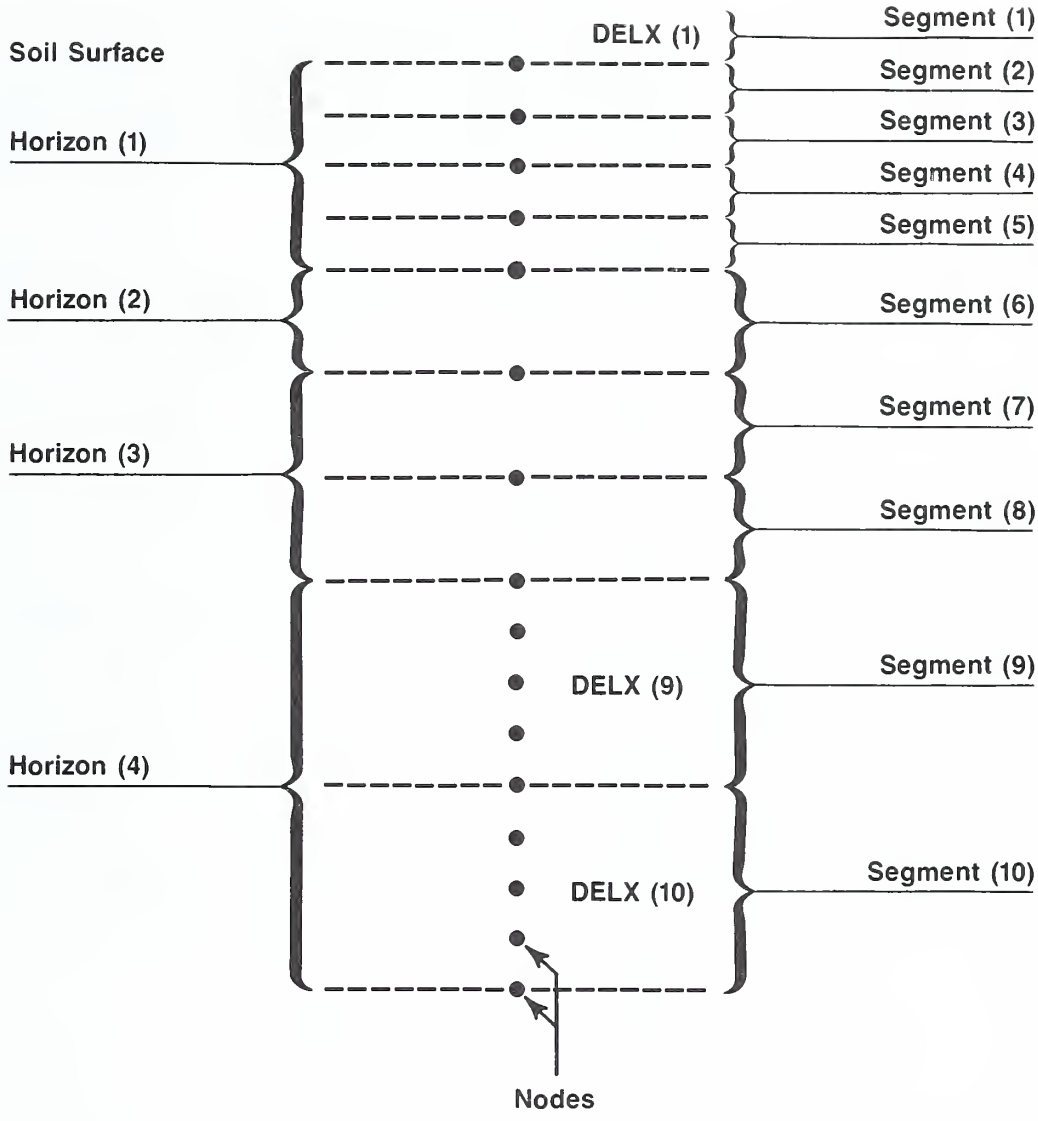

Figure 10
NTRM model horizon, segment, and nodal structure.

A considerable volume of model output is condensed in the form of two- and three-dimensional plot output files. The model is capable of producing a variety of plot types depending on user specifications and requirements. A summary of the plots that can be generated from each plot file is given in table 2.

Table 2.
NTRM model plot output summary

Plot file:	Plots generated
Tape 2 (Deep Percolation Plot File)	1. Cumulative leachate volumes (cm) vs. time. 2. Incremental leachate volumes (cm) vs. time. 3. NO_3^--N conc. in leachate (mg/L) vs. time. 4. NH_4^+-N conc. in leachate (mg/L) vs. time. 5. UREA-N conc. in leachate (mg/L) vs. time. 6. Ca^{++} conc. in leachate (mg/L) vs. time. 7. Na^+ conc. in leachate (mg/L) vs. time. 8. Mg^{++} conc. in leachate (mg/L) vs. time. 9. HCO_3^- conc. in leachate (mg/L) vs. time. 10. Cl^- conc. in leachate (mg/L) vs. time. 11. $CO_3^=$ conc. in leachate (mg/L) vs. time. 12. $SO_4^=$ conc. in leachate (mg/L) vs. time.
Tape 4 (Top Growth Plot File)	1. Total dry matter (tops) vs. time. 2. Leaf area (dm^2/plant) vs. time. 3. Corn grain production (kg/ha) vs. time. 4. N uptake demand (kg/ha) vs. time.
Tape 6 (Root Growth Plot File)	1. Total net root length produced (cm/cm^2 soil) vs. time. 2. Total root length produced (cm/cm^2 soil) vs. time. 3. Total root length sloughed (cm/cm^2 soil) vs. time. 4. Total root mass produced (kg/ha) vs. time.

Table 2--Continued
NTRM model plot output summary

Plot file:	Plots generated
Tape 7 (Root Distribution Plot File)	1. Crop root distribution vs. depth and time.
Tape 12 (Soil Nitrogen Plot File)	1. Total NH_4^+-N+NO_3^--N in soil (kg/ha) vs. time. 2. Daily plant uptake of N (kg/ha/day) vs. time. 3. Daily N leached (kg/ha/day) vs. time. 4. Daily N denitrified (kg/ha/day) vs. time. 5. Daily N fixed (kg/ha) vs. time. 6. NO_3^--N on soil surface (kg/ha) vs. time. 7. NH_4^+-N on soil surface (kg/ha) vs. time.
Tape 13 (3-D Plot File)	1. Root length (cm/cm^3 soil) vs. depth (cm) and time. 2. Soil temperature (°C) vs. depth (cm) and time. 3. Soil water content (cm^3/cm^3) vs. depth (cm) and time. 4. Soil suction (cm H_2O) vs. depth (cm) and time. 5. Soil bulk density (g/cm^3) vs. depth (cm) and time. 6. NO_3^--N conc. (mg/L) vs. depth (cm) and time. 7. NH_4^+-N conc. (mg/L) vs. depth (cm) and time. 8. UREA-N conc. (mg/L) vs. depth (cm) and time. 9. Ca^{++} conc. (mg/L) vs. depth (cm) and time. 10. Na^+ conc. (mg/L) vs. depth (cm) and time. 11. Mg^{++} conc. (mg/L) vs. depth (cm) and time. 12. HCO_3^- conc. (mg/L) vs. depth (cm) and time. 13. Cl^- conc. (mg/L) vs. depth (cm) and time. 14. $CO_3^=$ conc. (mg/L) vs. depth (cm) and time. 15. $SO_4^=$ conc. (mg/L) vs. depth (cm) and time.

Table 2--Continued
NTRM model plot output summary

Plot file:	Plots generated
Tape 14 (Soil Surface Plot File)	1. Random roughness (cm) vs. time. 2. Bulk density of uppermost segment (g/cm^3) vs. time. 3. Surface residue (mass) (t/ha) vs. time. 4. Percent cover vs. time. 5. Total water content (cm) of canopy vs. time. 6. Total water content (cm) of residue (mulch) vs. time. 7. Surface depression storage (cm) vs. time.
Tape 15 (N15 Plot File)	1. NO_3^--N (% N15) vs. time. 2. SNH_4^+-N (% N15) vs. time. 3. RNH_4^+-N (% N15) vs. time. 4. Soil OM (% N15) vs. time. 5. Residues (% N15) vs. time. 6. Plant N uptake (% N15) vs. time. 7. Leached N (% N15) vs. time. 8. Denitrified N (% N15) vs. time.
Tape 17 (Evapotranspiration Plot File)	1. Daily potential evaporation from soil surface (cm/mo) vs. time. 2. Daily potential transpiration (cm/mo) vs. time. 3. Daily potential ET (cm/mo) vs. time.

The basic data groups in the common input file needed to run the general NTRM model are illustrated in figure 11. Certain groups (see separate group descriptions) must be omitted when the nitrogen portion of the model is bypassed (NBYPAS = 1). Group 11 must be included when the salt portion of the model is bypassed (SBYPAS = 1). At all others times, group 11 is omitted.

In a similar manner, group 12 is included only when flow data are to be read from cards (ITEST = 1). When ITEST = 0, flow data are read from tape 1.

Group 14, the restart data, is not currently used in NTRM. The feature may be reactivated at a future date.

Group 21, Root Distribution, is present only when IVARR = 0. If the root growth model is used, IVARR = 2, group 21 is omitted.

Group 22, Plant Uptake of Nitrogen, is present only when CROP=3.

Group 23, Crop Growth Information (corn) is present only when CROP = 4.

Data groups 24 through 26 are the input data for the unsaturated flow submodel.

These data groups are similar to those used by previous independent versions of Unsaturated Flow. Modifications have been made in certain groups to accommodate the layered soil and modified boundary conditions.

Data Group 1--Title

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-80	A	TITLE	Any title desired on printed output. This character string will also appear in right margin of plotted output.

Data Group 2--Control Data

Column No.	Var. type	Var. name	Variable description
Line 1 of 4			
1-5	X	none	Not used by program.
6-10	X	none	Not used by program.

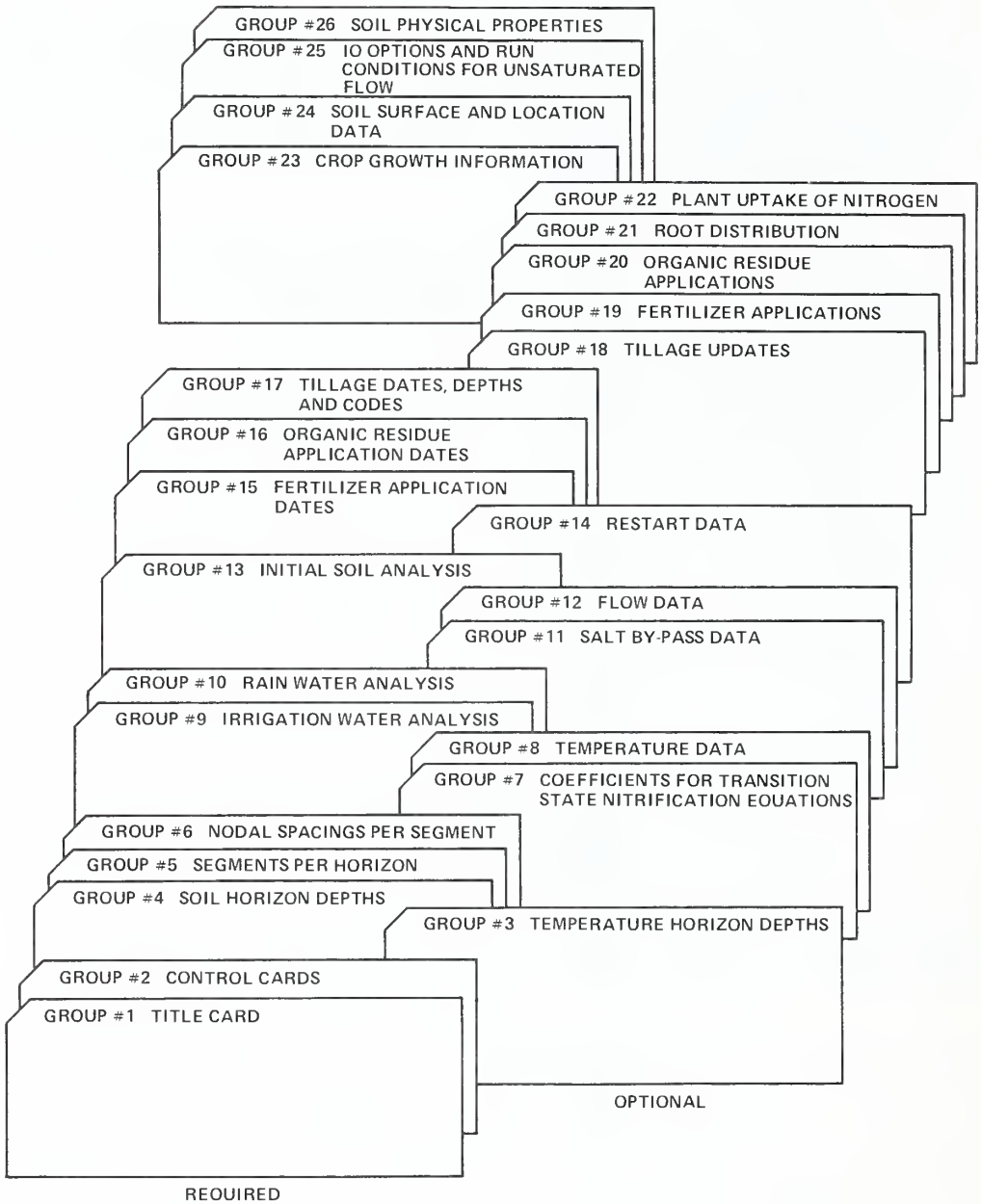
GROUP #26 SOIL PHYSICAL PROPERTIES
GROUP #25 IO OPTIONS AND RUN CONDITIONS FOR UNSATURATED FLOW
GROUP #24 SOIL SURFACE AND LOCATION DATA
GROUP #23 CROP GROWTH INFORMATION
GROUP #22 PLANT UPTAKE OF NITROGEN
GROUP #21 ROOT DISTRIBUTION
GROUP #20 ORGANIC RESIDUE APPLICATIONS
GROUP #19 FERTILIZER APPLICATIONS
GROUP #18 TILLAGE UPDATES
GROUP #17 TILLAGE DATES, DEPTHS AND CODES
GROUP #16 ORGANIC RESIDUE APPLICATION DATES
GROUP #15 FERTILIZER APPLICATION DATES
GROUP #14 RESTART DATA
GROUP #13 INITIAL SOIL ANALYSIS
GROUP #12 FLOW DATA
GROUP #11 SALT BY-PASS DATA
GROUP #10 RAIN WATER ANALYSIS
GROUP #9 IRRIGATION WATER ANALYSIS
GROUP #8 TEMPERATURE DATA
GROUP #7 COEFFICIENTS FOR TRANSITION STATE NITRIFICATION EQUATIONS
GROUP #6 NODAL SPACINGS PER SEGMENT
GROUP #5 SEGMENTS PER HORIZON
GROUP #4 SOIL HORIZON DEPTHS
GROUP #3 TEMPERATURE HORIZON DEPTHS
GROUP #2 CONTROL CARDS
GROUP #1 TITLE CARD
OPTIONAL
REQUIRED

Figure 11
Basic data groups in the common input
file needed to run the central NTRM model.

Column No.	Var. type	Var. name	Variable description
11-15	R	RSN	Rate of breakdown for soil humus (lb/acre/yr). (Shaffer nitrogen transformation (NT) model only.)
16-20	R	CH	Convergence criterion for nitrogen transformation routine. See note[1] for details. Suggested values are in the range 0.1-10.0 ppm nitrogen. (Shaffer NT model only)
21-25	R	CH1	Convergence criterion for chemical equilibria subroutine.[2] Suggested values are in the range $1 \cdot 10^{-2}$ $-1 \cdot 10^{-6}$ moles/L.
26-30	X	none	Not used by program.
31-35	X	none	Not used by program.
36-40	X	none	Not used by program.
41-45	X	none	Not used by program.
46-50	X	none	Not used by program.
51-55	R	FACT	Plant N-uptake constant (μg/cm) for use with consumptive-use values (if used).
56-60	R	SDATE	Emergence date (1-365).
Line 2 of 4			
1-5	I	LL	Julian starting day of run (1-365).
6-10	I	MM	Julian termination day of run (1-365).

[1]The constant CH determines the accuracy of the nitrogen changes computed in subroutine TRNSFM (Shaffer model). A Smaller value will increase accuracy and program execution time.

[2]The constant CH1 determines the accuracy of mass changes in the system computed in subroutine XCHANGE. A Smaller value will increase accuracy and program execution time.

Column No.	Var. type	Var. name	Variable description
11-15	I	O	Number of soil horizons (must be in range 1 to 10 inclusive) (see figure 5).
16-20	I	CROP	If = 1, transpiration used to determine N-uptake by plants. If = 2, reserved for future use. If = 3, read plant N-uptake data (see data groups 16 and 17). If = 4, crop growth submodel used (for corn).
21-25	I	TO	Number of temperature horizons (must be in range 1 to 4 inclusive). (Leave blank if ITEMP = 1, see group 2.)
26-30	I	NT	Number of weekly temperature data lines (must = 0 for NBYPAS = 1, see this group and group 8). (Leave blank if ITEMP = 11, see group 2.)
31-35	I	IPRINT	Print interval (days) for predicted soil chemistry data.
36-40	I	JPRINT	Time interval (1-10) within which the IPRINT and IMASS print options are to be activated.
41-45	I	INK	Write interval (days) for output to tape 2 (see "Pan Evaporation, Wind and Solar Radiation File").
46-50	X	none	Not used by program.
51-55	X	none	Not used by program.
56-60	X	none	Not used by program.
61-65	I	ITEST	If = 0, waterflow data are read from tape 1 or computed internally. If = 1, steady state waterflow data are read (see group 12).

Column No.	Var. type	Var. name	Variable description
66-70	I	ICAP	If = 1, upward movement of water allowed in plug flow submodel. If = 0, upward movement of water not allowed in plug flow submodel.
71-75	I	NCAP	Number of nodes associated with capillary fringe (from the bottom node upward).
76-80	I	KYEAR	Year for this run (for example, if this is the third year being run, KYEAR = 3).
Line 3 of 4			
1-5	I	KSTOP	Year when run terminates (for example, if run is to terminate after 33 years and starts with year 3, KSTOP = 5).
6-10	I	IMASS	Print interval (days) for summary of nitrogen balance for system.
11-15	I	IPRIN8	If = 0, printing of below is suppressed. If = 1, basic control data are printed.
16-20	I	IPRIN7	If = 0, printing of below is suppressed. If = 1, input data are printed.
21-25	I	NBYPAS	If = 0, nitrogen transformations are considered (Shaffer model or Molina model). If = 1, nitrogen transformations are bypassed, salt reactions remain in model if SBYPAS = 0.
26-30	I	SBYPAS	If = 0, salt reactions are considered. If = 1, salt reactions are bypassed; nitrogen transformations remain in the model if NBYPAS = 0.
31-35	I	NROTA	Number of years in crop rotation cycle.
36-40	I	NCLI	Number of years in climate cycle.

Column No.	Var. type	Var. name	Variable description
41-45	I	INFIL2	Starting file on output tape 2 (used when making a restart on tape 2 containing previous files).
46-50	I	INFIL1	Starting file on input tape 1 (used when more than 1 year's data are to be input to flow calculations).
51-55	I	ICONT1	If = 1, a new set of water application dates is read in each year. Also, no records can be skipped on tape 1.
56-60	I	IWRI3	If = 0, entire 3-D plot file (tape 13) is written. If = 1, first part of 3-D plot file is written.
61-65	I	IOP	If = 1, lime precipitation is checked in relation to available pore space. If = 0, option is bypassed.
66-70	I	IOPN	If = 1, transition-state nitrification subroutine used (Shaffer and Molina NT models). Coefficients must be read (see group 7). If = 0, statistical nitrification equation used (Shaffer model only).
71-75	I	IPCO2	If = 1, user supplies soil pCO_2 values (see group 13). If = 0, model estimates soil pCO_2 values.
76-80	I	IREK	If = 1, cation exchange coefficients for Ca-Na and Ca-Mg ion exchange are read from soils analysis data. If = 0, default values within program are used. (Ca-Na = 0.707 $(moles/L)^{-1/2}$ and Ca-Mg = 0.670 (unitless ratio)).

Column No.	Var. type	Var. name	Variable description
Line 4 of 4			
1-5	I	IVARR	Determines how root growth will be simulated. If = 0, constant root distribution from data group 21. If = 2, root growth model of Shaffer and Clapp (1982) is used.
6-10	I	ITEMP	Soil temperature control. If = 0, weekly soil temperatures are read in (group 8). If = 1, soil temperature model of Gupta et al. (1982) is used. (See section on soil temperature submodel for instructions.)
11-15	I	IDEMD	Demand control for crop growth model. If = 0, crop growth is interactive with nitrogen availability. If = 1, crop growth is based on ideal curve with respect to nitrogen.
16-20	I	IFLOW	Unsaturated flow model control. If = 0, unsaturated flow data must be supplied via tape 1 or data group 12. If = 1, unsaturated flow program in model is used.
21-25	I	INIT	Nitrogen transformation model control. If = 0, Shaffer NT model used. If = 1, Molina NT model used.
26-30	I	JSET	Root growth interaction control switch (Shaffer root growth model only). If = 0, root growth interactive with soil conditions. If = 1, root growth is ideal with respect to soil conditions.

Column No.	Var. type	Var. name	Variable description
31-35	I	N15	N15 nitrogen write-control switch. If = 0, N15 data not output to tape 15. If = 1, N15 data written to tape 15 on a daily basis.
36-40	I	IEVAP	If = 0, potential evaporation set equal to zero. If = 1, potential evaporation estimated from pan evaporation and ALAD.
41-45	I	IDAYP8	If = 0, semimonthly pan evaporation read from tape 81. If = 1, daily pan evaporation, wind, and solar radiation read from tape 81.
46-50	I	ITMOD	If = 0, tillage data not read. If = 1, tillage data read from group 18.
51-55	I	ITMSUB	If = 0, tillage data read from group 18 used in tillage calculations. If = 1, tillage submodels used to make tillage calculations.
56-60	X	none	Not used by program.
61-65	I	IMETH	If = 0, independent and cross-product terms used in root submodel. If = 1, multiplicative terms used. If = 2, minimum function used.
66-70	I	IPLUG	If = 0, unsaturated flow model is used. If = 1, plug flow model is used.
71-75	I	JEVAP	Number of nodes for surface evaporation (plug flow model only).
76-80	I	IWRI2	If = 0, deep percolation data are written in binary form. If = 1, deep percolation data are written in coded form.

Data Group 3--Temperature Horizon Depths

(Omit if NBYPAS = 1, or ITEMP = 1; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	R	THOR(J)	Depth (cm) from surface to bottom of first temperature horizon.
6-10[3]	R	THOR(J)	Depth (cm) from surface to bottom of second temperature horizon (if it exists). (J = subscript for each horizon.)

Data Group 4--Soil Horizon Depths

(Must always be present.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	R	HOR(J)	Depth (cm) from surface to bottom bottom of first soil horizon.
6-10[4]	R	HOR(J)	Depth (cm) from surface to bottom of second soil horizon.[5] (J = subscript for each horizon.)

Data Group 5--Segments per Horizon

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	I	ISEGN(J)	Number of segments in Jth horizon.
6-10	I	ISEGN(J+1)	Number of segments in horizon J+1.

[3]The program allows the inclusion of up to four temperature horizons. If included, the depths for numbers 3 and 4 would be in columns 11-15 and 16-20, respectively.

[4]The program allows inclusion of up to 10 soil horizons. If included, the depths for numbers 3, 4, 5, 6, 7, 8, 9, and 10 would be in columns 11-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, respectively.

[5]If only one soil horizon is desired, only one need be included.

Data Group 6--Nodal Spacings per Segment

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	I	INODE(J)	Number of nodal spacings per segment in Jth horizon.
6-10	I	INODE(J+1)	Number of nodal spacings per segment in J+1 horizon.

Data Group 7--Coefficients for Transition State Nitrification Equations

(Needed if IOPN = 1, see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	R	AINTN	Y intercept of activation energy vs. ionic strength relationship (default = 44.6 kcal/mole).
6-10	R	SLOPEN	Slope of activation energy vs. ionic strength relationship (default = 12.3 kcal•L/mole^2).

Data Group 8--Weekly Soil Temperature Date[6]

(Omit if NBYPAS = 1, or ITEMP = 1; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of NT[7]			
1-2	X	none	Card identification (not read by program).
3-10	R	TT(K)	Average weekly temperature (°C) for uppermost (first) temperature horizon.

[6]The first temperature data should correspond to the week beginning with the start of the run.

[7]NT is the number of temperature data lines. Each line contains weekly data for all temperature horizons.

	Column No.	Var. type	Var. name	Variable description
	11-20[8]	R	TT(K)	Average weekly temperature (°C) for second temperature horizon.[9] (K = subscript for weekly temperatures.)

Data Group 9--Irrigation Water Analysis

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			(all units in meq/liter of the species shown)
1-5	R	ANH3(1)	NH_4^+
6-10	R	ANO3(1)	NO_3^-
11-15	R	CA(1)	Ca^{++}
16-20	R	ANA(1)	Na^+
21-25	R	AMG(1)	Mg^{++}
26-30	R	HCO3(1)	HCO_3^-
31-35	R	CL(1)	Cl^-
36-40	R	CO3(1)	$CO_3^=$
41-45	R	SO4(1)	$SO_4^=$

Note: All irrigation water is assumed to have the same analysis.

Data Group 10--Rain Water Analysis

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			(all units in meq/liter of the species shown)
1-5	R	ANH3(1)	NH_4^+

[8]The program allows inclusion of up to four temperature horizons. If included, temperature data for horizons 3 and 4 would be in columns 21-30 and 31-40, respectively.

[9]If only one temperature horizon is desired, only one need be included.

Column No.	Var. type	Var. name	Variable description
6-10	R	ANO3(1)	NO_3^-
11-15	R	CA(1)	Ca^{++}
16-20	R	ANA(1)	Na^+
21-25	R	AMG(1)	Mg^{++}
26-30	R	HCO3(1)	HCO_3^-
31-35	R	CL(1)	Cl^-
36-40	R	CO3(1)	$CO_3^=$
41-45	R	SO4(1)	$SO_4^=$

Note: All rain water is assumed to have the same analysis.

Data Group 11--Salt Bypass Data

(Needed if SBYPAS = 1 and NBYPAS = 0; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of Q-1			
1-5	R	SERAT8(J)	Fraction of total NH_4^+ that is soluble NH_4^+.
6-10	R	U(J)	Ionic strength (moles/L) --needed only when IOPN= 1.
11-15	R	ACTCA(J)	Ca^{++} activity (moles/L) --needed only when IOPN = 1.

Data Group 12--Waterflow Data

(Needed only if ITEST = 1; if ITEST = 0, tape 1 must be used (IFLOW = 0; see Data Group 2) or internal unsaturated flow model can be activated (IFLOW = 1; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of NS[10]			
1-10	R	CMH2O1(J)	Volume of water in segment (cm^3).

[10] NS is the number of waterflow data lines. There must be a line for each segment including No. 1.

Column No.	Var. type	Var. name	Variable description
11-20	R	MOISIN(J)	Water movement across upper boundary of segment (cm^3/time step).[11]
21-30	R	MOISO8(J)	Water movement across lower boundary of segment (cm^3/time step).[11]
31-40	R	TEN(J)	Average water tension (cm) over time step (tensions shown as negative).
41-50	R	U(J)	Plant water uptake (cm/time step /soil segment).

Data Group 13--Initial Soil Analysis

Column No.	Var. type	Var. name	Variable description
Line 1 of NC[12]			(Units in meq/liter of species shown unless otherwise noted.)
1-5	R	ANH3(L)	NH_4^+ (soluble form). WARNING!! Never use total NH_4^+ here.
6-10	R	ANO3(L)	NO_3^-
11-15	R	UREA(L)	UREA
16-20	R	CA(1)	Ca^{++}
21-25	R	ANA(1)	Na^+
26-30	R	AMG(1)	Mg^{++}
31-35	R	HCO3(1)	HCO_3^-
36-40	R	CL(1)	Cl^-
41-45	R	CO3(1)	$CO_3^{=}$
46-50	R	SO4(1)	$SO_4^{=}$

[11] Positive sign for downward flow, negative for upward flow.

[12] NC is the number of soil horizons.

Column No.	Var. type	Var. name	Variable description
51-55	R	EC(1)	Exchange capacity (meq/100 g soil).
56-60	R	XX5(1)	Gypsum (meq/100 g soil).
61-65	R	CAL(1)	If = 0.0, no lime is present in soil. If = 1.0, lime is present in soil.
66-70	R	BD(1)	Bulk density (g/cm^3 of soil).
71-75	R	SAMT(1)	Soil organic nitrogen ($\mu g/g$ soil). (Shaffer NT model only.)
76-80	R	CN1(1)	Carbon-nitrogen ratio of soil organic matter (for example, 40:1 would be entered as 40.0). (Shaffer NT model only.)
Line 2 of set			
1-5	R	XTRCT(1)	g water/g soil in soil extract.
6-15	R	PCO2(1)	CO_2 partial pressure in atmospheres (needed only if IPCO2 = 1).
16-20	R	AKCS(1)	Ca-Na exchange coefficient (needed only if IREK = 1) default = 0.707 $(moles/L)^{-1/2}$.
21-25	R	AKCM(1)	Ca-Mg exchange coefficient (needed only if IREK = 1) default = 0.670 (unitless ratio).
26-30	R	CONC1(1)	Microbial mass ($\mu g/g$ soil, as carbon). (Molina NT model only.)
31-35	R	CONC2(1)	Nutrient humus ($\mu g/g$ soil, as carbon). (Molina NT model only.)

Data Group 14--Restart Data

(The current version of NTRM does not allow a restart; this option may be reactivated later.)

This data group is written by the program during a previous run.

Data Group 15--
Fertilizer
Application Dates

(Must always be present.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1[13]			
1-5	R	ITOT	Number of fertilizer applications.
6-10	I	IADD(K)	Julian date of first application.
11-15[14]	I	IADD(K)	Julian date of second application. (K = subscript for fertilizer applications.)

Data Group 16--
Organic Residue
Application Dates

(Omit if NBYPAS = 1; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	I	JTOT	Number of organic nitrogen (residue) applications.
6-10	I	IORNAP(K)	Julian date of first organic nitrogen application.
11-15[15]	I	IORNAP(K)	Julian date of second organic nitrogen application. (K = subscript for nitrogen applications.)

Data Group 17--
Tillage Dates,
Depths, and Codes

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-5	I	ITIL	Number of tillage events (max = 6).

[13]A second line may be used if needed (that is, if the number of applications exceeds 15, in which case the 15 format still applies).

[14]The program allows inclusion of up to 25 fertilizer application dates. The same format, 15, is used for any additional dates desired.

[15]This program allows inclusion of up to 5 organic nitrogen application dates. If included, application dates for applications 3, 4, and 5 would be in columns 16-20, 21-25, and 26-30, respectively.

Column No.	Var. type	Var. name	Variable description
6-10	I	ITILL(K)	Julian date of Kth tillage event.
11-16	R	TILLD(K)	Depth (cm) from surface to bottom of tillage.
17	I	ITCODE(K)	Tillage code (1 = moldboard plow, 2 = chisel plow, 3 = disk).

Repeat sequence up to 6 times.

Data Group 18--Tillage Updates

(Omit if ITMOD = 0; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of group			
Group repeated ITIL times.			
1-5	R	RR1(K)	Random roughness after Kth tillage event (0.0 - 4.0 cm).
6-10	R	PS1(K)	Soil reflection coefficient after Kth tillage event (0.0 - 1.0).
Line 2 of group			
This line repeated for each soil horizon.			
1-5	R	BD1(K,KD)	Bulk density (g/cm^3).
6-10	R	CK(K,KD)	Saturated hydraulic conductivity (cm/day).
11-15	R	CB(K,KD)	Campbell B coefficient.
16-20	R	CAE(K,KD)	Campbell air entry potential (cm).
21-25	R	THW(K,KD)	Water content at permanent wilt (cm^3/cm^3).
26-30	R	THS(K,KD)	Water content at saturation (cm^3/cm^3). (K = subscript for tillage event, KD = subscript for soil horizon.)

Data Group 19--
Fertilizer
Applications

(One line must be present even if blank; insert all fertilizer application lines as a single group.)

Column No.	Var. type	Var. name	Variable description
			Line 1 of NF[16]
			All units in lb/acre of species shown unless otherwise labeled.
1-5	R	FERT(1)	Depth (cm) of a uniform fertilizer application. If = 0.0, a surface application is indicated.
6-10	R	FERT(2)	NH_4^+ (0.0-400.0 lb/acre).
11-15	R	FERT(3)	NO_3^- (0.0-1,600.0 lb/acre).
16-20	R	FERT(4)	Urea (NH_2-$\overset{\overset{O}{\|}}{C}$-$NH_2$)(0.0-800.0 lb/acre).
21-25	R	FERT(5)	Ca^{++} (0.0-20,000.0 lb/acre).
26-30	R	FERT(6)	$SO_4^=$ (0.0-20,000.0 lb/acre).
31-35	R	FERT(7)	$CO_3^=$ (0.0-20,000.0 lb/acre).
36-40	R	FERT(8)	Fraction of N15 in NH_4^+-N (N15/(N14+N15)). (Molina NT model only).
41-45	R	FERT(9)	Fraction of N15 in NO_3^--N. (Molina NT model only).

[16]NF is the number of fertilizer applications. The maximum number allowed in the program is 25.

Data Group 20--
Organic Residue
Applications

(Omit if NBYPAS = 1; see Data Group 2; insert all organic matter application lines as a single group.)

Column No.	Var. type	Var. name	Variable description
Line of NO[17]			
1-5	R	DEPTH	Depth (cm) of residue application (equals 0 for surface applications).
6-10	R	ACN1	Carbon:nitrogen ratio of residue added (for example, 40:1 would be entered as 40.0).
11-15	R	SSAMT	Organic nitrogen added (lb/acre) as oven dry weight (0.0 - 100.0 lb/acre).
16-20	R	DELX(1)	Depth (cm) of residue on the surface (0-10cm).
21-25	R	PR1	Fresh residue reflection coefficient (0.0-1.0).
26-30	R	AICODE	Residue identification code (see table 3).
31-35	R	AKLAB	Specific rate coefficient for labile fraction (see table 3).
36-40	R	AKRES8	Specific rate coefficient for resistant fraction (see table 3).
41-45	R	S	Fraction of total residue that is labile (see table 3).
46-50	R	APER	Fraction of N15 in residue nitrogen application (N15/(N14+N15)) (Molina NT model only.)
51-55	R	AID	Pure carbon switch. If = 0.0, normal residue N application. If = 1.0, pure carbon is being added in SSAMT, (cols. 11-15), (lb C/acre). (Molina NT model only).

[17]No is the number of organic residue applications. The maximum number allowed in the program is 5.

Table 3.
Residue identification codes

AICODE		Values[1] for S	AKLAB[2]	AKRESIS[3]
0	Variable	User supplied	User or default	User or default
1	Corn stover	0.317	U or D	U or D
2	Wheat straw	.293	U or D	U or D
3	Cellulose	.098	U or D	U or D
4	Soybean straw	.566	U or D	U or D
5	Variable	([4])	U or D	U or D

[1]Default values are activated by leaving the data field blank.
[2]Default AKLAB = 0.044.
[3]Default AKRESIS = 0.00071.
[4]$S = 0.07 + 1.11\ (1.0/ACN1)^{1.0/3.0}$.

Data Group 21--Plant Root Distribution

(Omit if IVARR = 2; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-10	R	KP2(1)	Fraction (decimal) of plant roots from 0- to 1-foot depth.
11-20	R	KP2(2)	Fraction from 1 foot to 2 feet.
21-30	R	KP2(3)	Fraction from 2 feet to 3 feet.
31-40	R	KP2(4)	Fraction from 3 feet to 4 feet.
41-50	R	KP2(5)	Fraction from 4 feet to 5 feet.
51-60	R	KP2(6)	Fractions > 5 feet.

Data Group 22--Plant Uptake of Nitrogen

(Omit if CROP = 4; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of NP[18]			
1-10	X	none	Space for identification.
11-20	R	UPTK(K)	Plant uptake of nitrogen (lb-N/acre semimonthly). (K = subscript for each semimonthly period.)

Data Group 23--Crop Type and Coefficients

(Present only if CROP = 4; see Data Group 2.)

Column No.	Var. type	Var. name	Variable description
Line 1 of 1			
1-2	I	ICID	Crop Identification Code (1=corn, 2=sorghum, 3=sweet corn, 4=soybeans, 5=spring wheat, 6=winter wheat, 7=oats, 8=barley, 9=rye, 10=sunflowers, 11=potatoes, 12=alfalfa, 13=pasture grass, 14=sugar beets, 15=cotton, 16=peanuts, 17=tomatoes, 18=peas, 19=carrots, 20=sugarcane).
3-10	R	CLASS	Crop maturity class for corn (in days, for example, 85 = 85-day corn).
11-15	R	PPOP	Plant population (No. plants/ha).
16-20	R	DDTA	Growing degree days to flowering (optional: model will estimate if blank or zero).
21-25	R	DDMA	Growing degree days to maturity (optional: model will estimate if blank or zero).
26-33	A	ICROP8	Crop variety (for identification only).
34-38	R	AACOEF	Optional crop transpiration coefficient. Default=0.0085.
39-43	R	COEF1	Optional coefficient for photosynthesis. Default=65.0.

[18] NP is 24.

	Column No.	Var. type	Var. name	Variable description
	44-48	R	COEF2	Optional tops coefficient for respiration. Default=0.74.
	49-53	R	COEF3	Optional tops coefficient for production of leaves and stems. Defaults: corn=3.58, soybeans=4.10.
	54-58	R	COEF4	Optional tops coefficient for production of grain or other product. Defaults: corn=3.58, soybeans=3.00.
	59-63	R	COEF5	Optional tops coefficient for total drymatter production. Defaults: corn=0.0065, soybeans=0.0035.
	64-68	R	COEF6	Optional root coefficient for root branching (early stages).
	69-73	R	COEF7	Optional root coefficient for root branching (middle stages).

Data Group 24--Soil Surface and Location Data	Column No.	Var. type	Var. name	Variable description
	Line 1 of 3			
	1-10	R	RR	Random roughness (0.0 - 4.0 cm).
	11-20	R	PS	Soil reflection coefficient (0.0 - 1.0).
	21-30	R	SLOPE	Percent slope (0.0 - 50.0).
	31-40	R	SLOPEL	Slope length (meters).
	41-50	R	BDCOR	Bulk density of stabilized plow layer (g/cm^3).
	51-60	A	SLOPA8	Slope aspect (N, S, E, W, NE, NW, SE, SW).

	Column No.	Var. type	Var. name	Variable description
	Line 2 of 3			
	1-10	R	WIND	Long-term average total wind (km/day). (Note that daily wind values can also be input; set IDAYP8 = 1.)
	Line 3 of 3			
	1-10	R	LAT	Latitude of site location (degrees).
	11-20	R	ELEV	Elevation of site (meters).

Data Group 25--Input-Output Options and Run Conditions for Unsaturated Flow	Column No.	Var. type	Var. name	Variable description
	Line 1 of 2			
	1-5	X	none	Not used by program.
	6-10	X	none	Not used by program.
	11-15	X	none	Not used by program.
	16-20	I	ITENTH	Option to allow printed results to be output at 0.1-day intervals. If ITENTH = 1, print results every 10th day.
	21-25	X	none	Not used by program.
	26-30	X	none	Not used by program.
	31-35	X	none	Not used by program.
	36-40	X	none	Not used by program.
	41-45	X	none	Not used by program.
	46-50	X	none	Not used by program.
	51-55	I	IPOPT	Option to select the special form (Campbell method) of subroutine PROP to compute conductivities and diffusivities as a function of moisture content. If IPOPT = 1, then use this form. Campbell coefficients must then be included.

	Column No.	Var. type	Var. name	Variable description
	Line 2 of 2			
	1-5	I	AA	If AA = 1, print the initial input data.
	6-10	I	BB	If BB = 1, print computed water contents on a daily basis.
	11-15	I	CC	If CC = 1, read initial water contents from Group 26.
	16-20	X	none	Not used by program.
	21-25	X	none	Not used by program.
	26-30	R	BBC	Volumetric water content at the bottom boundary expressed as a decimal (dimensionless). (Note: This can be less than or equal to the saturated value.)
	31-35	X	none	Not used by program.
	36-40	X	none	Not used by program.
	41-45	X	none	Not used by program.
	46-50	I	M	Minimum number of time intervals per day for applying the finite difference solution.
	51-55	X	none	Not used by program.
	56-60	X	none	Not used by program.

Data Group 26--Soil Physical Properties	Column No.	Var. type	Var. name	Variable description
	Line 1 of variable			
	1-5	I	ICRACK	If = 0, soil is not a cracking soil. If = 1, soil is a cracking soil.
	6-10	I	ICRUST	If = 0, soil surface does not crust. If = 1, soil surface does crust.
	11-15	I	ICRCST	If = 0, soil crust does not crack. If = 1, soil crust does crack.

Column No.	Var. type	Var. name	Variable description
16-20	R	ARAN	Maximum rate of infiltration (cm/day) for normal soil.
21-25	R	ARACA	Maximum rate of infiltration (cm/day) for cracked soil.
26-30	X	none	Not used by program.
31-35	R	WSEAL	Precipitation amount (cm) on an unsealed soil above which sealing occurs.
36-40	R	THSEAL	Soil water content (θ) (cm^3/cm^3) on an unsealed soil above which sealing occurs.
41-45	R	THCR	Soil water content (θ) (cm^3/cm^3) below which cracking occurs.
46-50	R	ARACR	Maximum infiltration rate (cm/day) for crusted soil.
51-55	R	ARACR8	Maximum infiltration rate (cm/day) for a cracked crust.
Line 2 of variable (required if ICRUST = 1)[19]			
1-10	R	CRKSAT(1)	Saturated hydraulic conductivity (cm/day) for the crusted condition.
11-20	R	BEMPCR	Campbell B coefficient for the crusted condition.
21-30	R	AIREN7	Air-entry potential (cm) for the crusted condition.
31-37	R	CRTS	Saturated water content (θ) (cm^3/cm^3) for the crusted condition.
38-44	R	CRTD	Water content (θ) at permanent wilt (cm^3/cm^3) for the crusted condition.
45-51	R	CRTHI	Initial water content (θ) (cm^3/cm^3) for the crusted conditions.

[19]Crusted condition is assumed to occur in the uppermost soil horizon.

Column No.	Var. type	Var. name	Variable description
52-58	R	CRSAND	Percent sand for the crusted condition.
59-65	R	CRSILT	Percent silt for the crusted condition.
66-72	R	CRCLAY	Percent clay for the crusted condition.
Line 3 of variable (required if ICRCST = 1)			
1-10	R	CRKSAT(2)	Saturated hydraulic conductivity (cm/day) for the cracked crust condition.
11-20	R	BEMPC8	Campbell B coefficient for the cracked crust condition.
21-30	R	AIREC8	Air-entry potential (cm) for the cracked crust condition.
Line 4 of variable (always present),[20] indicates "normal" [21] soil			
1-10	R	KSAT(J,1)	Saturated hydraulic conductivity (cm/day) for normal soil.
11-20	R	BEMP(J)	Campbell B coefficient for normal soil.
21-30	R	AIRENT(J)	Air-entry potential (cm) for normal soil.
31-37	R	TS(J)	Saturated water content (θ) (cm^3/cm^3) for normal soil.
38-44	R	TD(J)	Water content (θ) at permanent wilt (cm^3/cm^3) for normal soil.

[20]A paired sequence of lines 4 and 5 must be repeated for each horizon.

[21]"Normal" soil defined as not cracked or crusted.

Column No.	Var. type	Var. name	Variable description
45-51	R	THI(J)	Initial water content (θ) (at start of run) (cm^3/cm^3) for normal soil.
52-58	R	SAND(J)	Percent sand for normal soil.
59-65	R	SILT(J)	Percent silt for normal soil.
66-72	R	CLAY(J)	Percent clay for normal soil.
73-79	R	TSM(J)	Leaching water content (cm^3/cm^3) for Jth horizon. (J = subscript for Jth horizon.)
Line 5 of variable (required if ICRACK = 1)[22]			
1-10	R	KSAT(J,2)	Saturated hydraulic conductivity (cm/day) for cracked condition.
11-20	R	BEMPCA(J)	Campbell B coefficient for cracked condition.
21-30	R	AIREN8(J)	Air-entry potential (cm) for cracked condition. (J = subscript for Jth horizon.)

[22]A paired sequence of lines 4 and 5 must be repeated for each horizon.

WATER APPLICATION FILE

This input file can be generated with the help of the interactive operating system (see "Interactive Generation of Input Files"). Otherwise, a suitable text editor or keypunch can be used to follow the formats as shown.

Column No.	Var. type	Var. name	Variable description
Line 1 of set			
11-13	I	APPS	Number of water applications (max = 99).
Line 2 of set			
*11-12	I	MON(I)	Month.
13-14	I	DATE(I)	Day.
15	A	ADENT(I)	Type of application, R = rain, I = irrigation.
16-21	R	AMT(I)	Depth of application (inches).
**22-26	X	none	Not used by program.
27-28	I	MON(I+1)	Month.
.	.	.	
.	.	.	
.	.	.	

Repeat from * to ** three times per line; last entry will be for columns 64-69 and will contain depth of application. Additional lines can be added if necessary. Maximum number of applications is 99.

PAN EVAPORATION, WIND, AND SOLAR RADIATION FILE

This particular input file has two possible structures depending on whether the input data are daily or semimonthly. Both formats can be generated with the assistance of the interactive operating system (see "Interactive Generation of Input Files").

For semimonthly inputs:

Column No.	Var. type	Var. name	Variable description
Line 1 of 2			
11-15	R	U1	Pan evaporation (inches) for Jan. 1-15.
16-20	R	U1	Pan evaporation (inches) for Jan. 16-end of month.
21-25	R	U1	Pan evaporation (inches) for Feb. 1-15.
.	.	.	
.	.	.	
.	.	.	

Repeat in semimonthly increments to:

66-70	R	U1	Pan evaporation (inches) for June 16-end of month.
Line 2 of 2			
11-15	R	U1	Pan evaporation (inches) for July 1-15.
.	.	.	
.	.	.	
.	.	.	

Repeat in semimonthly increments to:

66-70	R	U1	Pan evaporation (inches) for Dec. 16-end of month.

Note: Wind and solar radiation data are not included if semimonthly inputs are selected. This option may be added in the future.

For daily inputs:

Column No.	Var. type	Var. name	Variable description
Line 1 of N[1]			
*1-5	R	PAN	Pan evaporation (inches) for first day of week.
6-10	R	WIND	Wind run (km) for first day of week.
**11-15	R	SOLAR	Solar radiation (langleys) for first day of week.
16-20	R	PAN	Pan evaporation (inches) for second day of week.
.	.	.	
.	.	.	
.	.	.	

Repeat from * to ** for each day of week; last entry will be in columns 101-105.

A line is needed for each week of data included. First day should correspond to starting day of run.

[1]N is the number of weeks.

APPENDIX A--GENERAL SUMMARY OF OUTPUT FILES AND SPECIFIC FILE STRUCTURES

FILE	CONTENTS
Output	1. Summary of general control parameters and model input data. 2. Predicted soil profile data for major cations and nitrogenous species at specified times. 3. Mass balance status for nitrogenous species at specified times. 4. Miscellaneous monitoring information.
LU 2	Soil leachate data for flow volumes and soluble constitute masses becomes input to aquifier submodels.
LU 4	Daily output from crop growth model: 1. Total dry matter (tops) (kg/ha). 2. Leaf area (dm^2/plant). 3. Corn grain (kg/ha). 4. N uptake demand (kg/ha).
LU 6	Daily output from root growth model: 1. Total net root length produced (cm root/cm^2 soil). 2. Total root length produced (cm root/cm^2 soil). 3. Total root length sloughed (cm root/cm^2 soil). 4. Net root mass produced. 5. Root status (0-1 range).
LU 7	Daily summary of root distribution in each soil segment (for example, 15 cm).

LU 11	Daily summary from unsaturated flow model. 1. Basic monitoring parameters including cumulative leachate (cm) and evapotranspiration (cm). 2. Soil water contents (cm^3/cm^3) at each node. 3. Soil matrix potential (cm H_2O) at each node.
LU 12	Output summary from nitrogen transformation submodel (Molina).
LU 13	Root densities, soil water contents (θ) (cm^3/cm^3); soil matrix potential (ψ) (cm H_2O); soil temperatures (°C) as a function of time and depth (cm) (suitable for 3-D plots).
LU 14	Daily summary of surface conditions.
LU 15	Summary of N15 output from Molina submodel.
LU 17	Summary of daily evapo-transpiration.

Unsaturated Flow Input (LU 1)

Record	Type	Format	Variable	Contents
1	Binary	NA	I1	Dummy.
1	Binary	NA	I2	Dummy.
1	Binary	NA	I3	Dummy.
1	Binary	NA	I3	Dummy.
1	Binary	NA	CMH201(1)	Volume of water in segment 1 (cm/cm^2).
1	Binary	NA	MO1S1N(1)	Water flux into segment 1 (cm/cm^2).
1	Binary	NA	MO1S08(1)	Water flux out of segment 1 (cm/cm^2).
1	Binary	NA	TEN1(1)	Soil suction for segment 1 (+cm H_2O).
1	Binary	NA	U(1)	Transpiration for segment 1 (cm/cm^2).

Entire record sequence is repeated for each soil segment starting at the soil surface. NA = not applicable.

Soil Leachate Data (Input to Aquifer Submodels) (LU 2)	Record	Type	Format	Variable	Contents
	1	Coded	(1X,I5,	YEAR	Year number.
	1	Coded	I5,	IDAY	Julian day.
	1	Coded	F10.2,	DELN	Leachate for this time step (cm).
	1	Coded	F10.2,	CPPM(1)	Conc. NO_3^--N (mg/L) leached.
	1	Coded	F10.2,	CPPM(2)	Conc. NH_4^+-N (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(3)	Conc. UREA-N (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(4)	Conc. Ca^{++} (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(5)	Conc. Na^+ (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(6)	Conc. Mg^{++} (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(7)	Conc. HCO_3^- (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(8)	Conc. Cl^- (mg/L) leached for this time step.
	1	Coded	F10.2,	CPPM(9)	Conc. $CO_3^{=}$ (mg/L) leached for this time step.
	1	Coded	F10.2)	CPPM(10)	Conc. $SO_4^{=}$ (mg/L) leached for this time step.

Daily Output From Crop Growth Model (LU 4)	Record	Type	Format	Variable	Contents
	1	Coded	(7X,I3,	I	Julian day number.
	1	Coded	18X,E9.4,	PDRY	Total dry matter (tops) (kg/ha).
	1	Coded	15X,E9.3,	ALAD	Leaf area (dm^2/plant).
	1	Coded	19X,E9.4,	PEAR	Corn grain (kg/ha).
	1	Coded	21X,E8.3)	TNUPT8	N uptake demand (kg/ha).

Repeat record sequence for each Julian day.

Daily Output From Root Growth Model (LU 6)

Record	Type	Format	Variable	Contents
1	Coded	(7X,I5,	IDAY	Julian day number.
1	Coded	11X,F10.3,	RRTOT	Total net root length (cm root/cm^2 soil)
1	Coded	10X,F12.3,	TDM	Total root length produced (cm root/ cm^2 soil).
1	Coded	12X,F12.3,	TDEAD	Total root length sloughed (cm root/ cm^2 soil).
1	Coded	12X,F12.3,	ROOTM	Net root mass produced (kg/ha).
1	Coded	12X,F6.3)	RATIO	Root status (0-1 range).
	.			
	.			
	.			

Repeat record sequence for each Julian day.

Daily Summary of Root Distribution (LU 7)

Record	Type	Format	Variable	Contents
1	Coded	(9X,I5	IDAY	Julian day number.
1	Coded	7X,F5.0,	DELX(2)	DELX for segment 2.
1	Coded	12X,F7.3,	KP2(1)	Fraction of roots in segment 2.
1	Coded	F7.3,	DELX(3)	DELX for segment 3.
1	Coded	F7.3,	KP2(2)	Fraction of roots in segment 3.
	.	.	.	
	.	.	.	
	.	.	.	

Repeat to:

1	Coded	F7.3,	DELX(11)	DELX for segment 11.
1	Coded	F7.3)	KP2(10)	Fraction of roots in segment 10.
	.			
	.			
	.			

Repeat record sequence for each Julian day.

Output Summary From Nitrogen Transformation Submodel (Molina) (LU 12)	Record	Type	Format	Variable	Contents
	1	Coded	(1X,I5	IDAY	Julian day number.
	1	Coded	F7.1,	TAMNI	Total NH_4^+-N + NO_3^--N in soil (kg/ha).
	1	Coded	F7.1,	DPLT	Daily plant uptake of N (kg/ha).
	1	Coded	F7.1,	DOUT	Daily N leached (kg/ha).
	1	Coded	F7.1,	DDENIT	Daily N denitrified (kg/ha).
	1	Coded	F7.1,	SUMR11/10	Daily N fixed (kg/ha) --N on surface (kg/ha).
	1	Coded	F7.1,	ANO3(1)/10	NO_3^--N on surface (kg/ha).
	1	Coded	F7.1)	ANH3(1)/10	NH_4^+-N on surface (kg/ha).
	.				
	.				
	.				

Repeat record sequence for each Julian day.

Summary of Root and Soil Data for 3-D Plotting (LU 13)[1]	Record	Type	Format	Variable	Contents
	1	Coded	(1X,I5,	IDAY	Julian day number.
	1	Coded	I5,	JDEP1	Depth (cm).
	1	Coded	F8.3,	RTOT10/DELX	Root length (cm root/ cm^3 soil).
	1	Coded	F8.3,	TEM	Soil temperature (°C).
	1	Coded	F8.3,	CMH201/DELX	Soil water content (cm^3/cm^3).
	1	Coded	F10.3,	TEN1	Soil suction (cm water).
	1	Coded	F10.3,	BD	Soil bulk density (g/cm^3).
	1	Coded	F10.3)	ANO3/CMH201	NO_3^--N conc. (mg/L).
	2	Coded	(F10.3,	ANA/CMH201	Na^+ conc. (mg/L).
	2	.	.	ACA/CMH201	Ca^{++} conc. (mg/L).
	2	.	.	AMG/CMH201	Mg^{++} conc. (mg/L).
	2	.	.	HCO3/CMH201	HCO_3^- conc. (mg/L).
	2	.	.	CL/CMH201	Cl^- conc. (mg/L).
	2	.	.	SO4/CMH201	$SO_4^{=}$ conc. (mg/L).

[1]Entire file is shown; if option 1 is selected for IWRI3, salts are not included.

Repeat this sequence for each depth (segment) starting near the soil surface.

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Repeat the entire record for each Julian day.

Daily Summary of Surface Conditions (LU 14)

Record	Type	Format	Variable	Contents
1	Coded	(I5,	IDAY	Julian day number.
1	Coded	F10.3,	RR	Random roughness (cm).
1	Coded	F10.3,	BD(2)	Bulk density segment 2 (g/cm^3).
1	Coded	F10.3,	SURRES	Surface residue (kg/ha).
1	Coded	F10.3)	PCOVER	Percent cover.

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.

Repeat record sequence for each Julian day.

Summary of N15 Output From Molina Submodel (LU 15)

Record	Type	Format	Variable	Contents
1	Coded	(5X,49H,	Hollerith	Heading.
1	Coded	I5)	IDAY	Julian day number.
2	Coded	(5X,49H,	Hollerith	Heading.
2	Coded	5X,21H)	Hollerith	Heading.
3	Coded	(3X,I5,	I	Segment number.
3	Coded	F13.3,	PER8	TNH_4^+-N (% N15).
3	Coded	F18.3,	PER8S	SNH_4^+-N (% N15).
3	Coded	F14.3,	PER11	NO_3^--N (% N15).
3	Coded	F14.3,	PERMM	Microbial mass (% N15).
3	Coded	F14.3)	PERNH	Nutrient humus (% N15).

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Repeat record sequence for each Julian day and depth.

Summary of Daily Evapotranspiration Output (LU 17)	Record	Type	Format	Variable	Contents
	1	Coded	(1X,I2,	II	Julian day number.
	1	Coded	E12.4,	DEVE	Surface evaporation (cm/mo).
	1	Coded	E12.4,	DTRAN	Transpiration (cm/mo).
	1	Coded	E12.4,	DAYET	Evapotranspiration (cm/mo).
	1	Coded	E12.4,	DEVAP	Potential surface evaporation (cm/mo).
	1	Coded	E12.4,	POTRAN	Potential transpiration (cm/mo).
	1	Coded	E12.4,	POET	Potential evapotranspiration (cm/mo).
	1	Coded	E12.4,	1-TR	Fraction of radiation reaching ground.
	1	Coded	E12.4)	UDAY	Pan evaporation (cm/mo).
	.				
	.				
	.				

Repeat record sequence for each Julian day.

APPENDIX B--SAMPLE RUNS

Sample Interactive Session To Create Input Files for Soil Temperature Submodel

```
          GREETINGS -- PROCEDURE TO RUN NTRM SOIL TEMPERATURE
SUBMODEL


          ENTER CONTROL CODE:
               1= CREATE MAX-MIN AIR TEMPERATURE FILE
               2= CREATE GENERAL SOIL TEMPERATURE INPUT FILE
               3= CREATE BOTH FILES
3
 ENTER NAME OF NEW MAX-MIN AIR TEMP FILE:
NEWTEMP


          ROUTINE TO GENERATE MAX-MIN AIR TEMPERATURE FILE

          PLEASE ENTER YOUR JULIAN STARTING DAY
121


          ENTER MAX AND MIN AIR TEMPERATURES FOR EACH DAY.  USE
FREE FORMAT.
          ENTER -999,-999 WHEN FINISHED.  UNITS ARE DEGREES F.
          EXAMPLE:    56,45
71,40
70,57
65,54
59,52
60,47
58,44
60,39
59,47
51,39
54,35
60,35
60,51
67,41
73,41
77,43
74,46
61,54
71,45
73,39
78,44
81,47
77,59
70,60
62,54
59,52
64,60
71,54
69,56
```

```
77,59
70,49
76,42
80,55
77,54
74,53
78,49
83,60
83,53
87,57
70,56
72,55
-999,-999
```

MAX - MIN AIR TEMPERATURE FILE CREATED

ENTER NAME OF NEW GENERAL INPUT FILE FOR SOIL TEMP:

```
NESOTEM
```

ROUTINE TO SET UP GENERAL SOIL TEMPERATURE INPUT FILE.

ENTER YOUR JULIAN STARTING DAY AND NUMBER OF DAYS IN RUN.
USE FREE FORMAT.

```
121,40
```

ENTER INITIAL (AT TIME ZERO HOUR) SOIL TEMPERATURE
AT EACH OF THE INDICATED NODE DEPTHS (CM).
USE FREE FORMAT. UNITS ARE DEGREES C.

NODAL DEPTH (CM)

```
   .1    .2    .5   1.0   1.5   2.0   5.0  10.0  15.0  20.0
15,15,15,15,15,15,15,15,15,15
```

NODAL DEPTH (CM)

```
  25.   30.   35.   40.   45.   50.   55.   60.   65.   70.
15,15,15,15,15,15,15,15,15,15
```

NODAL DEPTH (CM)

```
  75.   80.   85.   90.   95.  100.  110.  120.  135.  150.
16,16,17,17,17,18,18,18,19,19
```

NODAL DEPTH (CM)

200. 250. 300. 350. 400. 450. 500. 550.
20,20,20,20,20,20,20,20

ENTER YOUR MANAGEMENT CODE:

1 = BARE SOIL

3 = 50 PCT. OAT RESIDUE COVER

5 = 75 PCT. OAT RESIDUE COVER

7 = 99 PCT. OAT RESIDUE COVER

9 = CORN + 50 PCT. OAT COVER

11 = CORN + NO RESIDUE COVER

11

GENERAL SOIL TEMPERATURE INPUT FILE CREATED

Contents of Example Max-Min Air Temperature File

```
121 71.0 40.0
122 70.0 57.0
123 65.0 54.0
124 59.0 52.0
125 60.0 47.0
126 58.0 44.0
127 60.0 39.0
128 59.0 47.0
129 51.0 39.0
130 54.0 35.0
131 60.0 35.0
132 60.0 51.0
133 67.0 41.0
134 73.0 41.0
135 77.0 43.0
136 74.0 46.0
137 61.0 54.0
138 71.0 45.0
139 73.0 39.0
140 78.0 44.0
141 81.0 47.0
142 77.0 59.0
143 70.0 60.0
144 62.0 54.0
```

```
145 59.0 52.0
146 64.0 60.0
147 71.0 54.0
148 69.0 56.0
149 77.0 59.0
150 70.0 49.0
151 76.0 42.0
152 80.0 55.0
153 77.0 54.0
154 74.0 53.0
155 78.0 49.0
156 83.0 60.0
157 83.0 53.0
158 87.0 57.0
159 70.0 56.0
160 72.0 55.0
```

Contents of Example General Input File for Soil Temperature Submodel

```
121
38
 .1  15.0  .2  15.0  .5  15.0 1.0  15.0 1.5  15.0 2.0  15.0
 5.0  15.010.0  15.015.0  15.020.0  15.025.0  15.030.0  15.035.0
15.040.0  15.0
45.0  15.050.0  15.055.0  15.060.0  15.065.0  15.070.0  15.075.0
16.080.0  16.0
 85.  17.0 90.  17.0 95.  17.0100.  18.0110.  18.0120.  18.0135.
19.0150.  19.0
200.  20.0250.  20.0300.  20.0350.  20.0400.  20.0450.  20.0500.
20.0550.  20.0
 40
  1
 11  1
  13.9  13.9  13.9  13.9  13.9  13.9
  13.9  13.9  13.9  18.4  18.4  18.4  22.1  22.1  22.1  27.7
27.7  27.7  27.5
  27.5  27.5  24.4  24.4  24.4  26.8  26.8  26.8  25.2  22.6
22.1  22.1  24.4
  24.4  24.4  24.4  24.4  24.4  24.4
```

Sample Interactive Session To Create Common Input File for NTRM Central Model

```
GENERATION SYSTEM FOR COMMON INPUT FILE(DECK)
     ENTER FILE NAME FOR NEW COMMON INPUT FILE TO BE CREATED:

NEWCOM
THE FOLLOWING ARE THE INPUT OPTIONS PRESENTLY AVAILABLE
IN THIS OPERATING PROCEDURE

     1.  DEFAULT OPTION 1 -- MINIMAL USER INPUT REQUIRED
     2.  DEFAULT OPTION 2 -- ALLOWS SELECTION OF SUBMODELS
                             UTILIZED, MORE USER INPUT MAY
                             BE REQUIRED

ENTER OPTION SELECTION

1
          INPUT TITLE DESIRED ON PRINTED OUTPUT
          (1 TO 80 CHARACTERS)

ROSEMOUNT 1981 -- TILL CASE

          THE FOLLOWING INPUT SETS TIME FRAMEWORK FOR THE
          SIMULATION RUN
          INPUT JULIAN DATES FOR THE FOLLOWING
          STARTING DATE OF THE RUN =
121
          TERMINATION DATE OF THE RUN =
160


          ENTER JULIAN DATE FOR CROP EMERGENCE
150
          THE FOLLOWING INPUT SETS SOIL  DATA
          INPUT NUMBER OF SOIL  HORIZONS (1 TO 10)

4
          INPUT DEPTH (CM) FROM SURFACE TO BOTTOM OF
          HORIZON 1
15
          ENTER NUMBER OF SEGMENTS FOR HORIZON 1

2

          ENTER NUMBER OF NODAL SUBDIVISIONS IN EACH
          SEGMENT (FOR HORIZON 1)

2
          INPUT DEPTH (CM) FROM SURFACE TO BOTTOM OF
          HORIZON 2
45
```

```
                ENTER NUMBER OF SEGMENTS FOR HORIZON 2
1
                ENTER NUMBER OF NODAL SUBDIVISIONS IN EACH
                SEGMENT (FOR HORIZON 2)
2
                INPUT DEPTH (CM) FROM SURFACE TO BOTTOM OF
                HORIZON 3
105
                ENTER NUMBER OF SEGMENTS FOR HORIZON 3
4
                ENTER NUMBER OF NODAL SUBDIVISIONS IN EACH
                SEGMENT (FOR HORIZON 3)
2
                INPUT DEPTH (CM) FROM SURFACE TO BOTTOM OF
                HORIZON 4
150
                ENTER NUMBER OF SEGMENTS FOR HORIZON 4
3
                ENTER NUMBER OF NODAL SUBDIVISIONS IN EACH
                SEGMENT (FOR HORIZON 4)
2
                INPUT THE FOLLOWING SOIL CHEMICAL ANALYSIS FOR
                CHEMICAL HORIZON    1

                ENTER NH4+ (SOLUBLE FORM) (MEQ/L)
                  (WARNING!!  NEVER USE TOTAL NH4+ HERE)
.001
                ENTER NO3-  (MEQ/L)
3.4
                ENTER UREA  (MEQ/L)
0
                ENTER BULK DENSITY (G/CM3 OF SOIL)
.95
                ENTER GM WATER/GM SOIL IN SOIL EXTRACT
.34
                ENTER MICROBIAL BIOMASS (UG/G SOIL) AS CARBON
10
```

```
                ENTER NUTRIENT HUMUS (UG/G SOIL) AS CARBON
500
                INPUT THE FOLLOWING SOIL CHEMICAL ANALYSIS FOR
                CHEMICAL HORIZON    2

                ENTER NH4+ (SOLUBLE FORM) (MEQ/L)
                  (WARNING!!  NEVER USE TOTAL NH4+ HERE)
.01
                ENTER NO3-  (MEQ/L)

2.4
                ENTER UREA  (MEQ/L)

0
                ENTER BULK DENSITY (G/CM3 OF SOIL)
.95
                ENTER GM WATER/GM SOIL IN SOIL EXTRACT
.34
                ENTER MICROBIAL BIOMASS (UG/G SOIL) AS CARBON
5
                ENTER NUTRIENT HUMUS (UG/G SOIL) AS CARBON
196
                INPUT THE FOLLOWING SOIL CHEMICAL ANALYSIS FOR
                CHEMICAL HORIZON    3

                ENTER NH4+ (SOLUBLE FORM) (MEQ/L)
                  (WARNING!!  NEVER USE TOTAL NH4+ HERE)
.01
                ENTER NO3-  (MEQ/L)

.60
                ENTER UREA  (MEQ/L)

0
                ENTER BULK DENSITY (G/CM3 OF SOIL)
.95
                ENTER GM WATER/GM SOIL IN SOIL EXTRACT
.34
                ENTER MICROBIAL BIOMASS (UG/G SOIL) AS CARBON

1
                ENTER NUTRIENT HUMUS (UG/G SOIL) AS CARBON
24
                INPUT THE FOLLOWING SOIL CHEMICAL ANALYSIS FOR
                CHEMICAL HORIZON    4

                ENTER NH4+ (SOLUBLE FORM) (MEQ/L)
                  (WARNING!!  NEVER USE TOTAL NH4+ HERE)
.01
```

ENTER NO3- (MEQ/L)

.60

ENTER UREA (MEQ/L)

0

ENTER BULK DENSITY (G/CM^3 OF SOIL)

.95

ENTER GM WATER/GM SOIL IN SOIL EXTRACT

.35

ENTER MICROBIAL BIOMASS (UG/G SOIL) AS CARBON

1

ENTER NUTRIENT HUMUS (UG/G SOIL) AS CARBON

2.3

ENTER MAXIMUM SURFACE INFILTRATION RATE (CM/DAY)

20

THE FOLLOWING WILL SET UP SOIL INFORMATION,
AND THE UNSATURATED FLOW PROPERTIES FOR EACH
SOIL HORIZON

ENTER SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY)
FOR HORIZON 1

20

ENTER CAMPBELL B COEFFICIENT FOR HORIZON 1

11.3

ENTER AIR-ENTRY POTENTIAL (CM) FOR HORIZON 1

15.3

ENTER SATURATED WATER CONTENT (CM^3/CM^3) FOR HORIZON 1

.30

ENTER SOIL WATER CONTENT (CM^3/CM^3) AT PERMANENT
WILT (AT 15 BARS) FOR HORIZON 1

.08

ENTER THE INITIAL SOIL WATER CONTENT (CM^3/CM^3) FOR
HORIZON 1

.22

ENTER PERCENT SAND FOR HORIZON 1

20

ENTER PERCENT SILT FOR HORIZON 1

20

ENTER LEACHING WATER CONTENT (CM^3/CM^3) FOR HORIZON 1

.22

ENTER SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY)
FOR HORIZON 2

20

ENTER CAMPBELL B COEFFICIENT FOR HORIZON 2

11.3

ENTER AIR-ENTRY POTENTIAL (CM) FOR HORIZON 2

15.3

ENTER SATURATED WATER CONTENT (CM^3/CM^3) FOR HORIZON 2

.30

ENTER SOIL WATER CONTENT (CM^3/CM^3) AT PERMANENT
WILT (AT 15 BARS) FOR HORIZON 2

.08

ENTER THE INITIAL SOIL WATER CONTENT (CM^3/CM^3) FOR
HORIZON 2

.22

ENTER PERCENT SAND FOR HORIZON 2

20

ENTER PERCENT SILT FOR HORIZON 2

20

ENTER LEACHING WATER CONTENT (CM^3/CM^3) FOR HORIZON 2

.22

ENTER SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY) FOR HORIZON 3

20

ENTER CAMPBELL B COEFFICIENT FOR HORIZON 3

11.3

ENTER AIR-ENTRY POTENTIAL (CM) FOR HORIZON 3

15.3

ENTER SATURATED WATER CONTENT (CM^3/CM^3) FOR HORIZON 3

.30

ENTER SOIL WATER CONTENT (CM^3/CM^3) AT PERMANENT WILT (AT 15 BARS) FOR HORIZON 3

.08

ENTER THE INITIAL SOIL WATER CONTENT (CM^3/CM^3) FOR HORIZON 3

.22

ENTER PERCENT SAND FOR HORIZON 3

20

ENTER PERCENT SILT FOR HORIZON 3

20

ENTER LEACHING WATER CONTENT (CM^3/CM^3) FOR HORIZON 3

.22

ENTER SATURATED HYDRAULIC CONDUCTIVITY (CM/DAY) FOR HORIZON 4

20

ENTER CAMPBELL B COEFFICIENT FOR HORIZON 4

11.3

ENTER AIR-ENTRY POTENTIAL (CM) FOR HORIZON 4

15.3

ENTER SATURATED WATER CONTENT (CM^3/CM^3) FOR HORIZON 4

.30

ENTER SOIL WATER CONTENT (CM^3/CM^3) AT PERMANENT WILT (AT 15 BARS) FOR HORIZON 4

.08

ENTER THE INITIAL SOIL WATER CONTENT (CM^3/CM^3) FOR HORIZON 4

.22

ENTER PERCENT SAND FOR HORIZON 4

20

ENTER PERCENT SILT FOR HORIZON 4

20

ENTER LEACHING WATER CONTENT (CM^3/CM^3) FOR HORIZON 4

.22

ENTER VOLUMETRIC WATER CONTENT AT THE BOTTOM NODE EXPRESSED AS A DECIMAL (DIMENSIONLESS)

.22

THE FOLLOWING GUIDES THE INPUT FOR THE EVAPORATION SUBMODEL

ENTER RANDOM ROUGHNESS (0.0 - 4.0 CM)

1.0

ENTER SOIL REFLECTION COEFFICIENT (0.0 - 1.0)

.5

ENTER PERCENT SLOPE (0.0 - 50.0)

0.0

ENTER SLOPE LENGTH (METERS)

0

ENTER STABILIZED BULK DENSITY OF SURFACE HORIZON
(0 < VALUE < 2.6 GM/CM^3)

1.2

ENTER LONG-TERM AVERAGE WIND TRAVEL (KM/DAY)

200

ENTER LATITUDE OF LOCATION (DEGREES)

41

ENTER ELEVATION OF LOCATION (METERS)

300

THE FOLLOWING WILL GUIDE IN THE INPUT
OF RAIN AND IRRIGATION WATER ANALYSIS

DO YOU WISH TO SET RAIN WATER ANALYSIS
TO DEFAULT VALUE OF 0.0. ENTER 1 FOR YES,
0 FOR NO

0

IS IRRIGATION WATER TO BE APPLIED
ENTER 1 FOR YES AND 0 FOR NO

0

ENTER THE FOLLOWING RAIN WATER ANALYSIS
(UNITS ARE MEQ/L)

ENTER NH4+

0.0

ENTER NO3-

0.1

ENTER CA++

0.0

ENTER NA+

0.0

ENTER MG++

0.0

```
                ENTER HCO3-

0.0
                ENTER CL-

0.0
                ENTER CO3=

0.0
                ENTER SO4=

0.0


                ENTER THE FOLLOWING CROP GROWTH DATA


                ENTER CROP MATURITY CLASS FOR CORN (IN DAYS)
                EX. 85=85 DAY CORN, 110=110 DAY CORN, ETC.
110
                ENTER PLANT POPULATION (PLANTS/HA)
53419
                ENTER UP TO 10 CHARACTER NAME OF CROP VARIETY
                PIONEER


                THIS PORTION OF THE PROGRAM GUIDES THE USER IN
                ENTERING TILLAGE INFORMATION

                ENTER NUMBER OF TILLAGE EVENTS (MAX=6)

1

                ENTER JULIAN DATE OF TILLAGE EVENT 1

124

                ENTER DEPTH (CM) OF TILLAGE FOR EVENT 1

30

                ENTER TILLAGE CODE.  1 = MOLDBOARD, 1
                2 = CHISEL PLOW,  3 = DISK

2
```

```
                THE FOLLOWING GUIDES IN FERTILIZER DATA INPUT

                INPUT THE NUMBER OF FERTILIZER APPLICATIONS
1
                ENTER APPLICATION DAY NUMBER 1 (JULIAN DATE)

136

                THE FOLLOWING WILL SET UP FERTILIZER APPLICATIONS
                FOR EACH FERTILIZER APPLICATION DATE


                ENTER DEPTH (CM) OF A UNIFORM FERTILIZER APPLICATION
                FOR APPLICATION DATE NUMBER    1
                (IF = 0.0 A SURFACE APPLICATION IS INDICATED)
                DEPTH =

0.0
                ENTER LBS/ACRE OF NH4+ ADDED IN APPLICATION    1
                TYPICAL RANGE 0.-400. LBS/ACRE
250
                ENTER LBS/ACRE OF NO3- ADDED IN APPLICATION    1
                TYPICAL RANGE 0.-1600. LBS/ACRE
0
                ENTER LBS/ACRE OF UREA ADDED IN APPLICATION    1
                TYPICAL RANGE 0.-800. LBS/ACRE
0
                ENTER LBS/ACRE OF CA++ ADDED IN APPLICATION    1
                RANGE 0.-20000. LBS/ACRE
0
                ENTER LBS/ACRE OF SO4= ADDED IN APPLICATION    1
                RANGE 0.-20000. LBS/ACRE
0
                ENTER LBS/ACRE OF CO3= ADDED IN APPLICATION    1
                RANGE 0.-20000. LBS/ACRE
0

                THE FOLLOWING GUIDES IN ORGANIC RESIDUE DATA INPUT


                INPUT NUMBER OF ORGANIC APPLICATIONS
1

                ENTER ORGANIC RESIDUE APPLICATION DAY (JULIAN)
                FOR APPLICATION NUMBER    1

323
                ENTER INCORPORATION DEPTH (CM) OF UNIFORM ORGANIC
                RESIDUE
```

```
          APPLICATION    1  (MUST BE A POSITIVE NUMBER)  ENTER
0.0
          FOR SURFACE APPLICATION

0.0
          ENTER CARBON:NITROGEN RATIO OF ORGANIC MATTER
          ADDED IN APPLICATION    1  (TYPICAL RANGE 15-80)
          C:N RATIO OF 40:1 IS ENTERED AS 40.0

40.
          ENTER ORGANIC NITROGEN ADDED (LBS/ACRE) AS OVEN
          DRY WEIGHT  (TYPICAL RANGE 0.-100. LBS/ACRE)

40

          ENTER DEPTH (CM) OF RESIDUE ON SURFACE
          (TYPICAL RANGE 0-10 CM)
0.5
          ENTER FRESH RESIDUE REFLECTION COEFFICIENT

0.0

          ENTER RESIDUE IDENTIFICATION CODE
               0 IF USER WANTS TO ENTER S, THE FRACTION OF
                 TOTAL RESIDUE WHICH IS LABILE
               1 IF CORN STOVER
               2 IF WHEAT STRAW
               3 IF CELLULOSE
               4 IF SOYBEANS
               5 IF S IS TO BE CALCULATED FROM THE EQUATION
                 S = 0.07 + 1.11(1/ACN1)''(1/3)

1
```

Contents of Example Common Input File for the NTRM Central Model

```
ROSEMOUNT 1981 -- TILL CASE
       .101000. 5.00.0001                                                150
  121  160    4    4    0    0   10   10    1
0               1
    1   10    1    1    0    1              1    1    0    1
0    0    0    0
    2    1    0    1    0    0    0    1    1    0    1    0
0    1    1    1
 15.0 45.0105.0150.0
    2    1    4    3
    2    2    2    2
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
0.000 .1000.0000.0000.0000.0000.0000.0000.000
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
  0.10.0020.001
 .0013.400 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00  .95 0.00 0.00
 .340     0.000   0.   0.  10. 500.
 .0102.400 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00  .95 0.00 0.00
 .340     0.000   0.   0.   5. 196.
 .010 .600 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00  .95 0.00 0.00
 .340     0.000   0.   0.   1.  24.
 .010 .600 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00  .95 0.00 0.00
 .350     0.000   0.   0.   1.   2.
    1  136
    1  323
    1  124 30.02
   0. 250.   0.   0.   0.   0.   0.
  0.0 40.0 40.0   .5 0.00    1.0000.00000.0000.0000.000
       11053419          PIONEER
     1.00       .50      0.00      0.00      1.20
    200.0
    41.000   300.000
                    0                                        1
    1    1    0           .220                   30       7.5
    0    0    0  20.
     20.00     11.30     15.30    .30    .08    .22  20.00
20.00  60.00    .22
     20.00     11.30     15.30    .30    .08    .22  20.00
```

```
20.00  60.00    .22
     20.00     11.30     15.30    .30    .08    .22  20.00
20.00  60.00    .22
     20.00     11.30     15.30    .30    .08    .22  20.00
20.00  60.00    .22
```

Sample Interactive Session To Create Pan Evaporation, Wind Run, and Solar Radiation Input File

```
 ENTER FILE NAME FOR NEW PAN EVAPORATION FILE:
NEWPAN
          THIS PROGRAM GUIDES THE USER IN THE INPUT
          OF PAN EVAPORATION DATA EITHER ON A SEMI-MONTHLY BASIS
          OR A DAILY BASIS.  IN THE LATTER CASE, DAILY WIND
          TRAVEL (KM/DAY) AND SOLAR RADIATION (LANGLEYS) ARE
          ALSO REQUIRED.

          CHOOSE ONE OF THE FOLLOWING OPTIONS FOR PAN EVAPORATION
               0.  SEMI-MONTHLY PAN EVAPORATION
               1.  DAILY PAN EVAPORATION (+ WIND + SOLAR)

1
          THE PROGRAM WILL PROMPT YOU IN THE INPUT
          OF DAILY PAN EVAPORATION, WIND TRAVEL, AND
          SOLAR RADIATION.  THE PAN EVAPORATION IS IN UNITS
          OF INCHES, WIND IS IN UNITS OF KM/DAY,
          AND SOLAR RADIATION IS IN UNITS OF LANGLEYS/DAY.
          (EX., .217,193,464)

          ENTER THE NUMBER OF DAYS OF THE SIMULATION RUN ON THE
          NTRM MODEL

40
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   1

.10,100.0,350.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   2

.10,100.0,200.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   3

.10,100.0,300.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   4

.10,100.0,250.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   5

.10,100.0,250.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   6

.10,100.0,250.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   7

.10,100.0,250.0
```

```
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   8

.10,100.0,250.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY   9

.10,100.0,250.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  10

.10,100.0,400.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  11

.16,100.0,400.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  12

.14,100.0,400.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  13

.28,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  14

.28,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  15

.23,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  16

.23,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  17

.23,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  18

.33,100.0,500.0
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  19

.25,100.0,695.6
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  20

.28,100.0,694.9
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  21

.49,100.0,655.9
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  22

.16,100.0,367.5
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  23

.16,100.0,241.1
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  24
```

```
.16,100.0,162.2
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  25

.12,100.0,125.4
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  26

.08,100.0,188.1
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  27

.10,100.0,424.4
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  28

.10,100.0,221.8
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  29

.26,100.0,572.8
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  30

.26,42.5,691.3
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  31

.26,42.5,461.3
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  32

.39,42.5,429.9
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  33

0.00,42.5,359.3
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  34

.19,42.5,448.8
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  35

.26,42.5,666.7
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  36

.33,194.7,626.9
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  37

.33,178.1,737.5
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  38

.33,208.5,378.5
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  39

0.00,218.0,298.5
          ENTER PAN, WIND, AND SOLAR DATA FOR DAY  40

.12,198.7,312.5
```

Contents of Example Pan, Wind, and Solar Input File

```
  .10100.0350.0  .10100.0200.0  .10100.0300.0  .10100.0250.0
.10100.0250.0  .10100.0250.0  .10100.0250.0
  .10100.0250.0  .10100.0250.0  .10100.0400.0  .16100.0400.0
.14100.0400.0  .28100.0500.0  .28100.0500.0
  .23100.0500.0  .23100.0500.0  .23100.0500.0  .33100.0500.0
.25100.0695.6  .28100.0694.9  .49100.0655.9
  .16100.0367.5  .16100.0241.1  .16100.0162.2  .12100.0125.4
.08100.0188.1  .10100.0424.4  .10100.0221.8
  .26100.0572.8  .26 42.5691.3  .26 42.5461.3  .39 42.5429.9
0.00 42.5359.3  .19 42.5448.8  .26 42.5666.7
  .33194.7626.9  .33178.1737.5  .33208.5378.5 0.00218.0298.5
.12198.7312.5
```

Sample Interactive Session To Create Precipitation and Irrigation Input File

```
ENTER FILE NAME FOR NEW WATER APPLICATION FILE:
WSAVE

          THIS PROGRAM GUIDES THE USER IN THE
          INPUT OF WATER APPLICATIONS DATA FOR NTRM

          ENTER A NUMERIC IDENTIFIER CODE
12345

          ENTER YEAR OF THE RUN, EX., 1981
1981

          ENTER NUMBER OF WATER APPLICATIONS
          (MAXIMUM NUMBER IS 60)
8

          ENTER ALPHANUMERIC DESCRIPTION TO IDENTIFY
          THE WATER APPLICATIONS
PRECIP

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  1 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0503I


          ENTER AMOUNT OF APPLICATION   1 AS A
          VOLUME PER UNIT AREA (INCHES)
.88

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  2 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0504R
```

```
          ENTER AMOUNT OF APPLICATION   2 AS A
          VOLUME PER UNIT AREA (INCHES)
.15

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  3 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0508R


          ENTER AMOUNT OF APPLICATION   3 AS A
          VOLUME PER UNIT AREA (INCHES)
.15

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  4 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0523R


          ENTER AMOUNT OF APPLICATION   4 AS A
          VOLUME PER UNIT AREA (INCHES)
.80

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  5 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0528R


          ENTER AMOUNT OF APPLICATION   5 AS A
          VOLUME PER UNIT AREA (INCHES)
.37

          ENTER MONTH,DATE OF MONTH,
          AND AN ALPHANUMERIC IDENTIFIER CODE
          FOR THE TIME OF WATER APPLICATION  6 AND TYPE
          (EX., 0121R=JANUARY 21, RAIN)
0601R


          ENTER AMOUNT OF APPLICATION   6 AS A
          VOLUME PER UNIT AREA (INCHES)
.05
```

```
                ENTER MONTH,DATE OF MONTH,
                AND AN ALPHANUMERIC IDENTIFIER CODE
                FOR THE TIME OF WATER APPLICATION  7 AND TYPE
                (EX., 0121R=JANUARY 21, RAIN)
0602R

                ENTER AMOUNT OF APPLICATION   7 AS A
                VOLUME PER UNIT AREA (INCHES)
.08

                ENTER MONTH,DATE OF MONTH,
                AND AN ALPHANUMERIC IDENTIFIER CODE
                FOR THE TIME OF WATER APPLICATION  8 AND TYPE
                (EX., 0121R=JANUARY 21, RAIN)
0607R

                ENTER AMOUNT OF APPLICATION   8 AS A
                VOLUME PER UNIT AREA (INCHES)
.17
```

Contents of Sample Precipitation and Irrigation Input File

```
12345 1981  8PRECIP
          0503I  .88     0504R  .15     0508R  .15     0523R
.80
          0528R  .37     0601R  .05     0602R  .08     0607R
.17
```

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Gupta, S.C., J.K. Radke, and W.E. Larson. 1987. Soil temperature submodel. In M.J. Shaffer and W.E. Larson (eds.), NTRM, a Soil-Crop Simulation Model for Nitrogen, Tillage, and Crop-Residue Management, U.S. Department of Agriculture Conservation Research Report 34-1.

Ribbens, R.W. 1976. Technical description of return flow quality simulation model-quantity portion. U.S. Department of the Interior, Bureau of Reclamation, Engineering and Research Center, 113 pp.

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